December 2015

Safe and Sustainable Tourism: Managing Venice's Millions of Visitors

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Safe and Sustainable Tourism: Managing Venice's Millions of Visitors

An Interdisciplinary Qualifying Project submitted to the faculty of Worcester Polytechnic Institute

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December 19th, 2015

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Authorship

Each team member's contribution to this project was essential and each member contributed an equal amount of work. The project would not have been successful without the hard work of each member and the collective work of the team. Each team member's individual contributions are described below.

Christopher Connor

The main author of several sections of the report and the team member responsible for keeping the project on track. Chris was also the lead presenter during both the final presentation and meetings throughout the project term.

Thomas Hanna

Contributed a large amount of writing to the report and was the primary designer of large sections of the presentation. Tommy also contributed to editing many sections of the paper and led most of the team's fieldwork efforts.

William Van Rensselaer

The main contributor to most of the heavily technical aspects of the project. Specifically, Will created the train arrivals, AirBnB, and tourist presence widgets produced for this project. He also created many of the infographics used in both the report and presentation.

Zachary Wingerter

The main contributor to most of the mathematical analysis in this project. Zach also contributed to writing the report. He designed the project website.

Acknowledgments

Professor Fabio Carrera
For his crucial guidance and feedback with respect to all areas of our project.
Professor Lorraine Higgins
For her constant helpful feedback on our project. Her edits and suggestions were instrumental to our final paper.
Professor Jim Chiarelli
For his huge assistance in the beginning of the development of our proposal. His moral support really aided our progress towards our final product.
Tomaso Minnelli and Francesco D'Este
For their expertise in computer programming and and help with the Venice Dashboard.
Piero Toffolo
For his expertise in GIS layering and constant support in all areas of our project.
Marco Scurati
For taking the time to talk to us about S. Marco Pass.
Roberta Bartoloni
For taking the time to talk to us about Venezia Libera.
Andrea Casadei
For taking the time to talk to us about Pass4Venice.
Paolo Lanapoppi
For taking the time to talk to us about Ven-us and Italia Nostra.
Cristiano Farina and Marco Bonaventura
For taking the time to talk to us about ZTL Revolution and the 5-Star Movement.
Paolo Corposanto
For his help with our train arrivals widget.

Abstract

Venice is visited by millions of tourists every year, which makes life difficult for the city's residents. To help solve the problems tourism brings, the team built a proposal for tourism management. To construct this proposal, the team determined the current occupancy of the city, estimated the maximum safe occupancy, using international standards, and drew on the most feasible features of five existing tourism management proposals.

Executive Summary

Every year, Venice is inundated with millions of visitors who, though bringing millions of euros in revenue, can make life difficult for the city's permanent residents. Venice's visitors are split into two groups: daytripper tourists, who come to the city only for a day, and overnight tourists, who stay overnight in the city. Oftentimes, large groups of daytrippers clog up streets and cause overcrowding, yet they do not contribute as much as overnighters to the city's economy.

In order to deal with the problems tourism brings, there have been several proposals made to manage the city's tourists. For most of these proposals, managing tourism in Venice involves setting a limit on the number of tourists allowed to enter the city, requiring tourists to register their visit in advance, and incentivizing tourists to stay overnight rather than just visiting for the day.

None of these proposals, however, have used safety as the key criteria on which to limit the number of tourists in the city. Also, many of these proposals are not based on sufficiently reliable data regarding the occupancy Venice. Much of this occupancy data exists, but is scattered amongst a variety of sources, such as the Italian Census, the city's Annuario del Turismo, reports by the Consortium for Research and Educational Training (COSES), and previous work by the Venice Project Center.

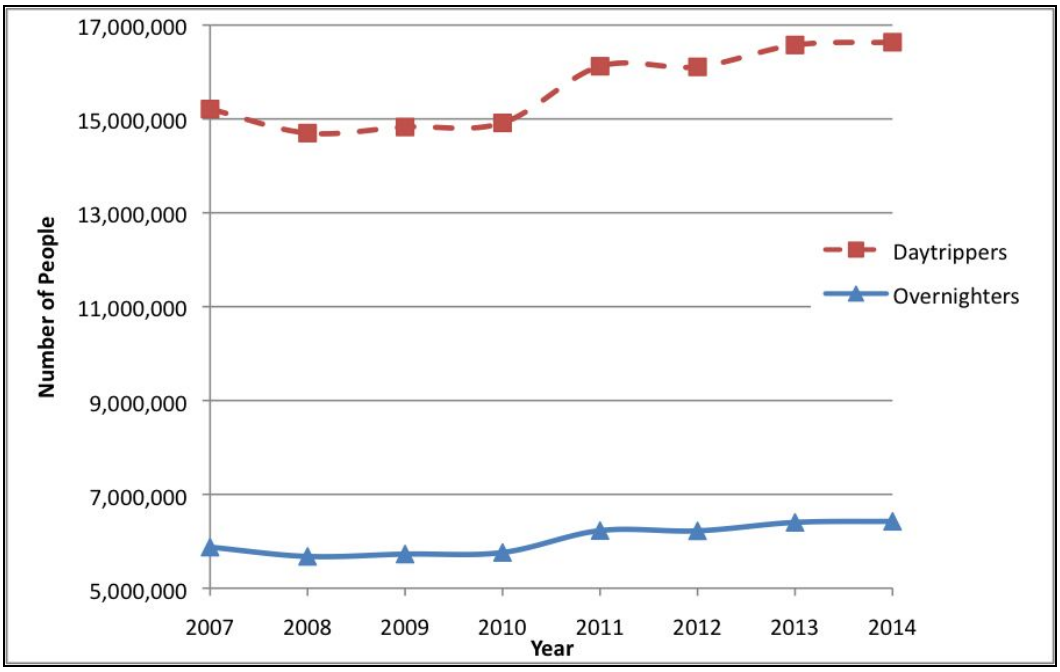
In order to determine a safe occupancy limit for Venice, the team utilized international safety standards specified by the European Committee for Standardization.These standards posit that an evacuation of a given area should take no more than eight minutes, as after eight minutes, panic sets in and people will get hurt. Additionally, it has established that 66 people should be able to exit an area per minute per meter of egress. Using these safety parameters, the maximum occupancy of any given area is given by the equation:

$$Maximum\ Occupancy = Flow\ Rate * Time * Egress\ Width$$

The goal of this project was to help the city of Venice reduce the negative impacts of tourism while promoting safety and prosperity. To accomplish this goal, the team set four objectives: 1) determine the current occupancy of Venice, using the data described above; 2) estimate a maximum occupancy based on the above safety formula; 3) evaluate five of the more prominent tourism management proposals for some of the best, most feasible ideas; and 4) outline a new tourism management plan using the maximum occupancy value we identified.

Current Occupancy of Venice

The occupancy of historic Venice is the sum of daytripper tourists, overnight tourists, commuters, and residents in the city each day. The team consulted the city's 2014 Annuario del Turismo and 2009 COSES report to determine the yearly number of overnighters and commuters. Census data provided the city's resident population. The number of daytrippers in the city required estimation. To do this, we determined the growth trend in overnight tourists based on Annuario data over several years. We then used the same growth rate to project a total number of daytripper tourists since 2007, as we had that earlier data point from COSES.

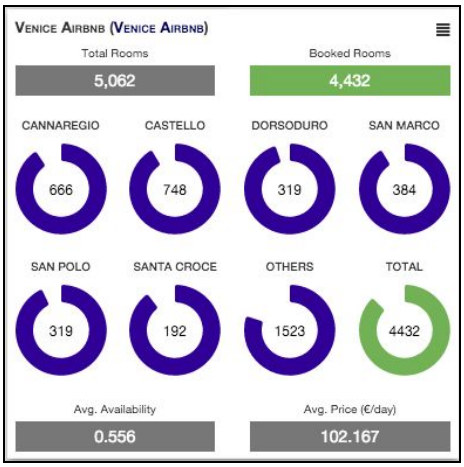


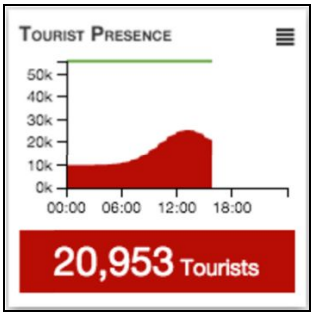
Given our calculations, the current occupancy of Venice per year and by day for 2014 is summarized below.

	Overnighters	Daytrippers	Commuters	Residents
Daily	**17,600**	**45,580**	**22,700**	**55,700**
Annual	**6,425,000**	**16,635,000**	**7,600,000**	**20,330,000**
Percentage	**12.6 %**	**32.6 %**	**14.9 %**	**39.9 %**

To help with future occupancy predictions, the team also collected data on all train arrivals in Venice and used those numbers to project future daily arrivals of tourists and commuters through a widget on the Venice Project Center Dashboard, which contains many other data based widgets to help understand tourism and other city data on a day-by-day basis. We also determined AirBnB guests in the city using internet data scrapers and built a widget to display this data by area of the city, which can supplement information about hotel stays already displayed on the Dashboard. Finally, we created a

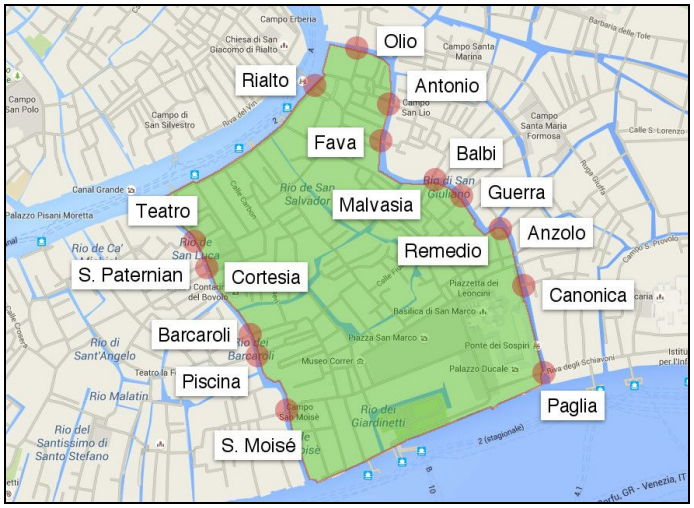
tourist presence widget, which tracks the overall presence of tourists in the city throughout the day and visually compares that to the city's current resident population. These three widgets can be seen below.



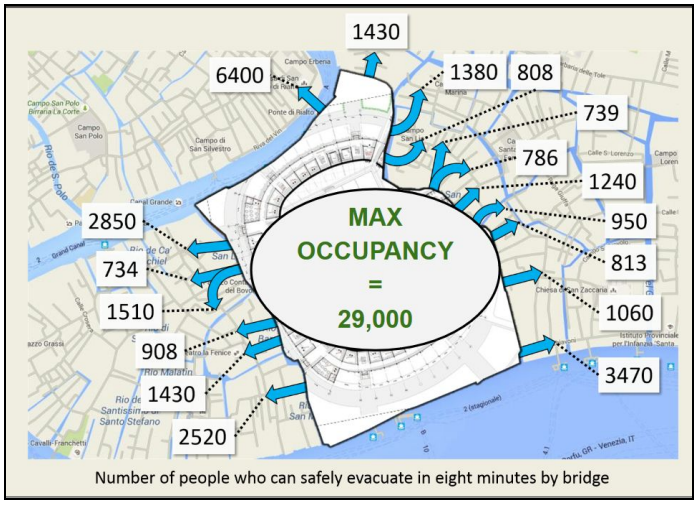


Maximum Occupancy of Venice

The maximum occupancy of Venice is necessary for developing a tourism management plan. We used the maximum occupancy formula for safe evacuation described earlier and applied it to a test area.



This area represents the most popular area of Venice, which is the area from Rialto Bridge to Piazza San Marco. In the event of an evacuation, this most crowded area would present the highest risk for crowding, bottlenecking, and trampling. The 17 usable bridges leading out of the area would serve as the exits, and these were measured to determine the area's egress width. Using our maximum occupancy equation, we found that 29,000 people can safely occupy the area. These numbers are visualized in the infographic to the left.



Number of people who can safely evacuate in eight minutes by bridge

The team knew that this area of analysis was the most popular area of the city for tourists. Further, nearly all tourists spend at least some part of their stay in this area. As a result, we reasoned that the maximum occupancy of this area dictates the maximum occupancy of the entire city. Since residents and commuters must be in the area, and since overnight tourists bring in revenue, we decided to focus on reducing the number of

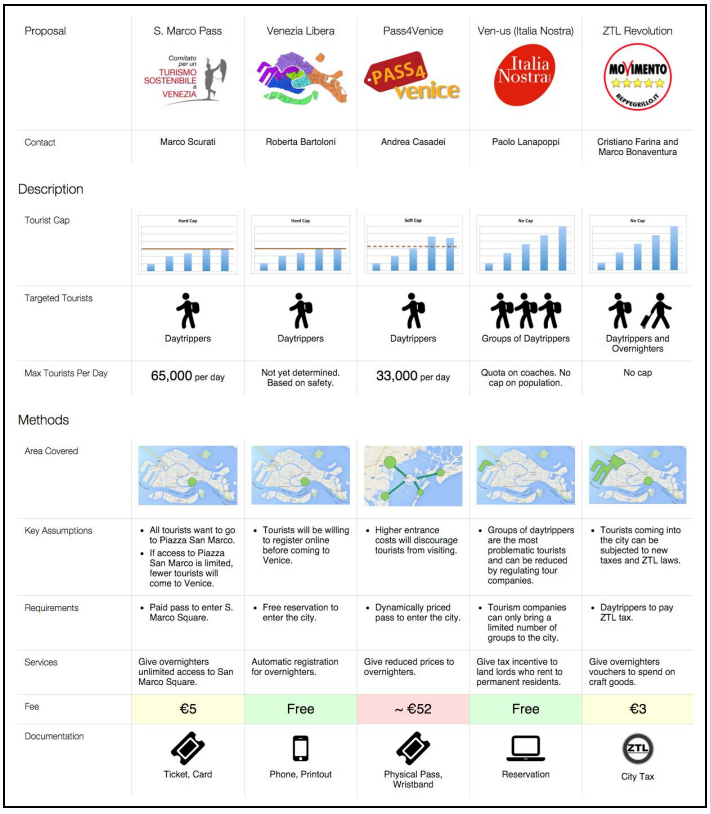
daytrippers to meet our maximum occupancy value. The maximum number of daytrippers can be found by subtracting from out of the 29,000 person limit the number of residents, commuters, and overnighters likely to be in the area of analysis during the day. This equation is visualized below.

Max Daytrippers = Occupancy - # of Residents - # of Commuters - # of Overnighters

Overall, the group found that a maximum of 6 million daytripper tourists per year can be safely allowed into the area, and thus the city.Meeting this number would require a 64% reduction in the current number of daytrippers who visit Venice per year. Combining this number of daytrippers with the current overnight tourists equates to an overall maximum of 34,120 tourists per day that can be safely allowed into the city.

Outlining a New Tourism Management Proposal

The team analyzed five tourism management proposals: S. Marco Pass, Venezia Libera, Pass4Venice, Ven-us, and ZTL Revolution, producing a matrix that summarized the tourist caps, goals, and strategies of each. This matrix can be seen in miniature to the left, and in full on page 70-71 of the report.



Proposal	S. Marco Pass	Venezia Libera	Pass4Venice	Ven-us (Italia Nostra)	ZTL Revolution
Contact	Marco Scurati	Roberta Bartoloni	Andrea Casadei	Paolo Lanapoppi	Cristiano Farina and Marco Bonaventura
Description					
Tourist Cap					
Targeted Tourists	Daytrippers	Daytrippers	Daytrippers	Groups of Daytrippers	Daytrippers and Overnighters
Max Tourists Per Day	65,000 per day	Not yet determined. Based on safety.	33,000 per day	Quota on coaches. No cap on population.	No cap
Methods					
Area Covered					
Key Assumptions	• All tourists want to go to Piazza San Marco. • If access to Piazza San Marco is limited, fewer tourists will come to Venice.	• Tourists will be willing to register online before coming to Venice.	• Higher entrance costs will discourage tourists from visiting.	• Groups of daytrippers are the most problematic tourists and can be reduced by regulating tour companies.	• Tourists coming into the city can be subjected to new taxes and ZTL laws.
Requirements	• Paid pass to enter S. Marco Square.	• Free reservation to enter the city.	• Dynamically priced pass to enter the city.	• Tourism companies can only bring a limited number of groups to the city.	• Daytrippers to pay ZTL tax.
Services	Give overnighters unlimited access to San Marco Square.	Automatic registration for overnighters.	Give reduced prices to overnighters.	Give tax incentive to land lords who rent to permanent residents.	Give overnighters vouchers to spend on craft goods.
Fee	€5	Free	~ €52	Free	€3
Documentation	Ticket, Card	Phone, Printout	Physical Pass, Wristband	Reservation	City Tax

The group used the knowledge gained from analyzing the five tourism manage proposals to create a 3-stage outline (short, medium, and long term strategies) to manage the city's tourists and keep the occupancy of the city capped at a safe level. All of these stages focus on limiting daytripper tourists rather than overnighters, as daytrippers contribute far less to the city's economy than overnighters, while also contributing more to the crowding problems that the city experiences.

The first stage of the new tourism management proposal would begin as soon as possible given the urgency of the tourism problem in Venice. The key ideas in this stage are:

1. Registration for use of city services
    a. Offer a free registration for daytrippers and automatic registration by hotels for overnighters.
    b. Making a reservation allows tourists to access public transport and civic museums. Those without registrations cannot use these services.
    c. Limit the number of registrations to the 34,120 tourists per day safety cap.
2. Public information campaign
    a. Make all potential tourists aware of the new tourism management plan.
    b. Encourage tourists to register in advance or stay overnight.
3. Limit the number of large, daytripper tour groups
    a. Regulate the number of busloads of daytrippers that tour companies can bring in.
4. Expand existing ZTL laws, which restrict where buses are allowed to come into the city
    a. Apply ZTL laws to boats and cruise ships to help control where tourists enter the city.

The second stage of the team's tourism management plan, which can be implemented in less than five years, is an expansion of the measures implemented in the first stage. It involves the follow key aspects:

1. Mandatory registration to enter the city
    a. Make the optional registration process in stage one mandatory.
    b. Without a registration, tourists would not be able to enter the city.
    c. Maintain a reservation cap at the 34,1200 tourists per day safe limit.
2. Control access to the city using entrance gates
    a. Check registrations as tourists are entering the city.
    b. Create a checkpoint system at key city entrances, namely Piazzale Roma and Ferrovia.
3. Optionally, attach a small city tax to registrations
    a. Help to cover the costs of the management program by making daytrippers pay the same city tax that overnighters already do.

The third stage of the plan, taking more than five years to fully implement, is an optional stage which should only be implemented if the measures taken in the first two stages are unable to effectively manage tourism. The key aspects of this stage are:

1. Control access using entrance hubs around the city
    a. Make tourists show their pass before entering the city.
    b. Make it mandatory for everyone to enter the city via these hubs.
2. Optionally, charge tourists to buy tickets to enter the city
    a. Cover the costs of the program and generate income for the city.

This outline of strategies for a 3-stage management plan was delivered to the city for future consideration and development. With such a plan, the team hopes that Venice will be able to more effectively regulate the number of tourists coming into the city and keep its occupancy at a safe and sustainable level. This will alleviate the problem of overcrowding and allow the city's permanent residents to lead better daily lives and enjoy the beautiful city they call home.

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1. Introduction

Historical cities are among the most popular tourist destinations, yet many of these cities are not built to handle large numbers of visitors. They can face logistical and transportation issues in trying to accommodate thousands of visitors, especially considering that these cities often have winding, narrow streets. Large crowds in these areas can cause damage, as well as a great deal of congestion, making daily life for permanent residents difficult. Managing tourism is an important issue in today's world, as historical cities are not just a nice places to visit, but they are also someone's home.

One historic city that is a particularly popular tourist destination is Venice, Italy. As a UNESCO World Heritage city, Venice has achieved worldwide recognition for its history, rich architecture, and artistic achievements. In total, Venice hosts over 23 million tourists each year and the number is increasing; the city can experience a surge of over 90,000 visitors daily during the peak tourist season.[1]

With only 55,700 permanent residents currently living in the city, tourists can outnumber Venetians two to one at various times of the year.[2] Since Venice is such a small city, at just 2.02 square miles for the city proper, this large volume of tourists becomes problematic. The tourism industry in Venice is vital to the city's income however. While tourism costs the city of Venice an estimated 74.4 million Euros a year, the tourism industry also brings an estimated 2.3 billion Euros in overall revenue for the city's economy.[3] For this reason, Venice's problem with tourism is not economic, but rather it is with the sheer number of visitors in the city, who clog up streets, crowd markets, and increase boat traffic. As a result, residents find it difficult to move around the city and accomplish their daily tasks.

The large number of tourists also can affects the safety of visitors and Venetians alike. Venice consists of over 100 individual islands that are connected by bridges, but only one connects the city to the mainland. Excluding this bridge, the only other exit from Venice is by boat. With so few forms of egress out of the city, an unexpected evacuation could be very dangerous. The problem is further compounded by the fact that Venice has numerous narrow streets and canals. In the event of an emergency, it would be very difficult for people to find effective evacuation routes. Instead, crowds might clog up the narrow streets and entrap those trying to get out of the city. During large events like the Biennale art festival, the problem only gets worse.

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[1] Blanco et al, p.13
[2] City of Venice, "Time series"
[3] Blanco et al, p.35

Currently, several proposals created by various organizations and citizens aim to address this crowding. Some of these focus on limiting tourism by setting a hard limit on the number of tourists allowed to enter Venice. Other proposals set a soft cap on tourism by implementing incentives and disincentives for visiting the city. The local consensus is, however, that something needs to be done and soon.

The problem is that, in most cases, these proposals lack hard data to justify how they limit tourism. Moreover, none of them set limits based on rigorous calculations of safe occupancy, but rather seem to assume relatively arbitrary comfortable occupancy values. A more robust proposal for managing the influx of tourists is needed to truly solve the problem, one that takes into account reliable tourism data, pedestrian movement, and safety parameters established by experts.

Past publications by both the Venice Project Center (VPC) and the city of Venice, with its annual Annuario del Turismo[4] and the COSES report[5], have documented specific data on tourism. There is an opportunity to develop a concrete tourism management plan based on this data (and updates to it), and so in this project the team sought to use this data and collect new data, to assess the range of ideas currently proposed by groups around the city and to propose a maximum occupancy level based on safety calculations. This data-based approach allowed the team to compare the various existing plans, as well as to create a new sustainable tourism management plan supported by informed numbers and calculations. Specifically, this project determined how many pedestrians it would take to create an unsafe evacuation scenario in Venice's most congested area. Setting a maximum occupancy for Venice below this level will help to promote a safe and sustainable environment for the city's residents and millions of visitors.

[4] Mar, et. al, *Annuario del Turismo 2014*
[5] Scaramuzzi et al, *COSES*

2. Background

This chapter discusses the historical preservation and infrastructure (as shown in Figure 2.1) of Venice. Also discussed in this chapter is the resident population of the city, tourism in Venice, and the interaction between tourists and permanent residents. All of these factors affect crowding, the negative consequences of which are also discussed. Finally, this chapter includes information on current tourism management and past work that has gone into understanding tourism in the city.

Figure 2.1 Bird's eye view of historic Venice[6]

2.1 Preserving the Historical City of Venice

Venice is widely regarded as historically and culturally significant. For this reason, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) listed the city and its lagoon as a World Heritage site. UNESCO helps to protect and preserve places of cultural and natural heritage in the world and encourages States Parties (countries adhering to the World Heritage Convention) to establish management plans and report on the conservation of their World Heritage.[7] Thanks to careful preservation, Venice still retains a great deal of its history within its city limits after 1600 years of existence.

[6] M & M Art Studio
[7] "World Heritage"

According to UNESCO's World Heritage entry on Venice, the city was made a World Heritage site because of the unique landscape of the city's 126 constituent islands, its rich history as a world trade power, and its remarkable concentration of artistic masterpieces.[8] UNESCO highly values the influence of Venice in architectural and monumental arts, as well as the city's historic position as a link between the Eastern and Western world. Unfortunately, UNESCO recognizes that Venice is still in danger despite preservation efforts.[9] The most pressing management issues include flooding, tourism pressure, and the maintenance of traditional practices and techniques for restoration. UNESCO puts particular focus on the issue of tourism in Venice and places a sustainable tourism strategy as one of Venice's Management Plan priorities.[10]

2.2 Venice's Infrastructure

The historic infrastructure of Venice amplifies the effects of tourism, as it leads to a great many people being crowded into small streets. Venice's unique structure as a collection of individual islands makes an organized grid system of streets impossible. Instead, Venice consists of over 2,650 small, curved streets that meet at irregular intersections[11]. The city's public transportation system is limited to canal boats and to walking, since there aren't any automobile roads in Venice. Bikes cannot be used within the city either, as they pose a risk to other pedestrians. A map of Venice's roads on the island of San Marco can be seen in Figure 2.2.

Figure 2.2 Map of Venice's roads in the sestiere of San Marco[12]

[8] "Venice and Its Lagoon"
[9] Ibid
[10] Ibid
[11] "Streets"
[12] Luestling. Venice, Italy: The City

Even though there are over 2,650 streets within the city of Venice, there is only one bridge that connects the city to the mainland.[13] Ponte della Liberta is a 3.85 km bridge that connects Venice and Mestre, Italy.[14] The bridge consists of two train rails and a double lane of automobile traffic. Upon arrival in Venice, tourists have to park their cars or disembark from trains and buses in order to enter the city. Furthermore, there are only four bridges that span the Grand Canal, which cuts through the center of the city. They are the Ponte di Rialto, Ponte dell'Accademia, Ponte della Costituzione, and the Ponte degli Scalzi. Without using one of these four bridges, it is impossible to leave eastern Venice on foot.

The size of Venice's streets is also very problematic for pedestrian travel. Within the city, walkways sometimes shrink to just shoulder width. These small pathways create bottlenecks, where only a very small number of people can pass through an area at one time. Some of these tight streets are also occupied by tables and chairs of restaurants, or even vendors and merchandise stands. As such, bottlenecking causes mobility issues and could pose a very serious problem in the event of an evacuation.

With so many tourists in the city, it would be easy for different paths in the city to become completely blocked during an evacuation. In this way, it can be said that the design of the streets in Venice is not meant to support the estimated 170,000 people that may occupy Venice on any given day in the peak season.[15] Therefore, these narrow roads, combined with the numerous dead ends created by Venice's many canals and buildings, not only create traffic issues on a regular day in Venice, but are potentially very dangerous in the case of an emergency.

2.3 Residential Life in Venice

Venice's infrastructure and tourist presence affect the residential life for local Venetians, whose population has been declining since the early 1950's. The peak Venetian population occurred in 1952 with 174,000 living in the historic city. Since then, the population has decreased to 55,700 permanent residents.[16] This decline can be seen in Figure 2.3.

[13] "Streets"
[14] Capula et al, p.22
[15] Blanco et al, p.12-13
[16] "Time Series"

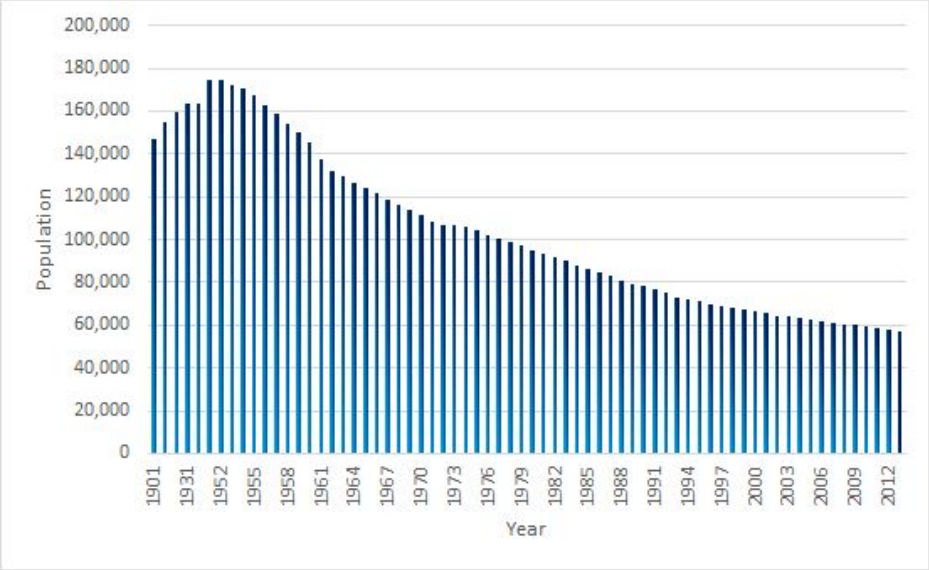


Figure 2.3 Annual resident population over the 20th Century[17]

A major issue for residential life in Venice is that residents are constantly outnumbered by tourists. On average, the number of tourists per day is close to 57,430[18]. So on an average day, there can be as many tourists as there are Venetians moving about the city. Figure 2.4 shows the average daily number of tourists and residents each month, displaying how there can be more visitors in the city than there are residents. This sheer volume of tourists leads to congestion and pedestrian traffic, making daily activities like going to the grocery store difficult. In fact, this issue is so significant that it has achieved global attention. The mayor of Barcelona, Spain has even said that he doesn't want his city to "end up like Venice."[19] Author Elizabeth Becker agrees, claiming that Venice is a "lost cause," and that it is growing impossible to lead a residential life in the city.[20]

[17] "Time Series"
[18] Blanco et al., p.13
[19] Matlack
[20] Ibid

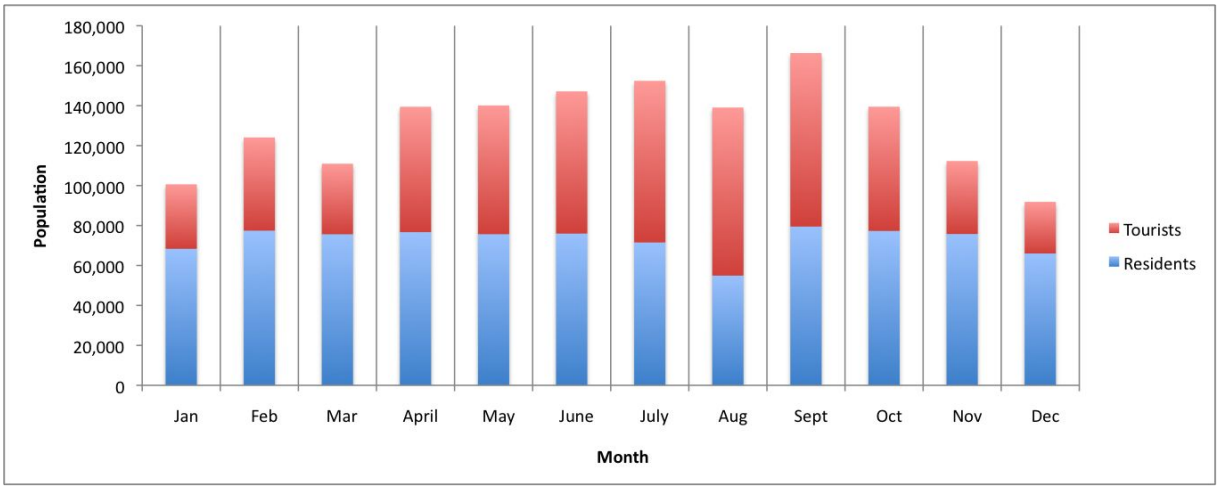


Figure 2.4 Average daily number of tourists and residents each month in 2013[21]

The decrease in the population of Venice can be majorly attributed to high costs of living driven by the tourism industry. Food, real estate, and transportation are expensive and employment opportunities are narrowing and migrating toward tourist-oriented businesses. Local business owners and landlords raise prices to increase profit margins from wealthy tourists. Unfortunately, many residents can't afford this high cost and must leave the city because, according to Alessandro Burbank, a 26-year-old Venice resident, "a normal life in Venice with a house, a job, a wife, a family, no longer exists."[22] One study has even predicted that in 15 years, there will no longer be any full time residents.[23] In order to dramatically portray the declining resident population, in 2008 a group of Venetian residents staged a mock funeral for the resident population of Venice.[24]

The huge number of tourists in Venice and soaring real estate prices are causing public outrage. As seen in Figure 2.5, local residents are taking to social media to advocate for change.

Figure 2.5 A local resident urging change on Twitter

[21] Blanco et al, p.12-13
[22] "The Death of Venice: Corrupt Officials, Mass Tourism and Soaring Property Prices."
[23] Ibid
[24] Ibid

Additionally, the tourist centers of Venice contain plenty of graffiti urging visitors to leave. Figure 2.6 is a blunt example on a temporary wall on the Rialto Bridge. Figure 2.7 shows similar graffiti near San Maurizio, where a depiction of a stereotypical tourist can be seen.

Figure 2.6 Graffiti on the Rialto Bridge construction zone

Figure 2.7 Graffiti near San Maurizio

2.4 Tourism in Venice

Tourists are attracted to Venice's culture, history, art, and architecture. Once a world power, Venice's history as a sea trading power introduced wealth and prosperity into the city. Despite their age, many buildings in Venice remain pristine and are engineering marvels for their time. During the Renaissance, musicians and artists alike came to Venice in search of inspiration. Today, Venice has transformed from a trade-focused to a tourism-focused economy. In fact, tourism has become so common that the city can experience upwards of 23 million tourists per year (see Figure 2.8) Consequently, the idea of limiting tourism is a controversial topic. It is important to take into account both the economic and political aspects of tourism in order to devise an effective tourism management solution.

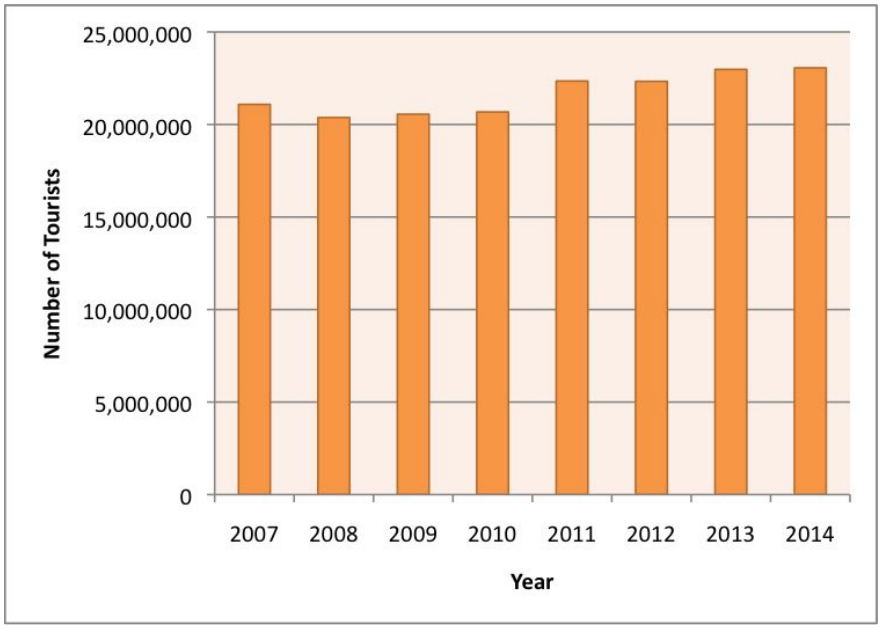


Figure 2.8 Estimated Tourists in Venice per year

Other than Venice's beauty and history, tourists are attracted to the city because of events. The most notable is the Biennale, an art festival that takes place during the fall of every odd numbered year. The tradition was established in 1895 and currently attracts over 370,000 visitors.[25] An example of an exhibit at the Biennale can be seen in Figure 2.9. Events like Biennale are noteworthy because they can cause congestion. Popular exhibits can attract large crowds of tourists that restrict pedestrian flow.

[25] *History of the Venice Biennale.* La Biennale di Venezia

Figure 2.9 An exhibit at the Biennale[26]

Tourists that visit the city can be separated into two distinct categories: daytrippers and overnighters. As the name implies, a daytripper is someone who stays for a few hours in the city, but not overnight. An overnighter is any person who stays for one or more night in the city. It is important to understand this distinction because of their individual effects on the city. Overnighters are favored in Venice because they represent only 20% of tourism, yet they contribute 80% of the tourism industry's revenue.[27] Daytrippers, on the other hand, provide minimal economic benefit, while also making population movement more difficult by clogging up Venice's narrow streets. This is especially true of daytrippers in tour groups. These groups move around in large clumps, then stop at interesting locations. This makes it very difficult for other people to navigate Venice's streets, as these tour groups can often take up entire streets.

Other than congestion problems, the presence of millions of tourists each year physically degrades Venice. The best way to understand the resulting physical damage is to quantify it monetarily: garbage removal, pollution, and *moto ondoso* (boat wakes) costs. While staying in the lagoon, tourists generate a lot of trash that needs to be collected and carried out of the city to landfills or recycling plants. In total, tourists generate 75 tons of trash per day, a yearly cost of 44.8 million euros.[28] On a similar note, tourists cause a lot of pollution during their stay. Pollution costs, such as sewage removal and CO_2 emissions, cost the city approximately 20.6 million euros per year[29]. Another cost to the city stems from the erosion of canal walls from *moto ondoso*. Boat wakes are not new to the city of Venice; however, the influx of tourism puts the

[26] Kielnhofer. "Illuminations at the Biennale."
[27] Blanco et al, p.28
[28] Ibid
[29] Blanco et al, p.30

city public transportation under a lot of stress. Repeated abuse from the boat wakes costs the city almost 9 million euros in canal wall repairs per year. All together, tourists do generate a lot of income, but they also cost the city of Venice roughly 74.3 million euros a year and damage precious infrastructure.[30] Optimizing the number of tourists in the city can help to both alleviate these problems as well as increase the tolerance for tourism amongst native Venetians.

The economic benefits of tourism do outweigh the costs. While in the city, tourists spend large amounts of money for hotels, food, and transportation. The greatest contribution to Venice's income is the revenue from hotels and overnight stays.[31] In total, tourists bring in 397.4 million euros per year in tax revenue, more than five times the costs associated with tourism. Thus tourism nets 323 million Euros of income for the Italian government,[32] and is viewed as necessary to the economic well-being of Venice.

2.5 Tourism Management

In order to effectively manage the large number of tourists entering Venice every year without disrupting the economic benefits that tourism provides the city, Venice is looking to adopt a tourism management plan. A variety of proposals for tourism management exist and all of them approach the problem of managing tourists in different ways, such as through hard and soft caps on the number of tourists that can enter the city, and through various disincentives and incentives that would either limit the number of tourists or influence their length of stay in the city. This project assessed these five proposals, to better weigh the options: Pass4Venice, San Marco Pass, ZTL Revolution, Venezia Libera, and Ven-us.

2.5.1 Tools for Tourism Management

When considering a problem like tourism management, the government of Venice has six tools it can consider utilizing (Table 2.1).[33]

[30] Blanco et al, p.35
[31] Blanco et al, p.17
[32] Blanco et al, p.35
[33] Carrera, p.7

Table 2.1 Tools of government[34]

Tool	Description
Own and Operate	Ownership and operation refers to the government's right to change or improve anything in the city which the government owns. This might refer to government-managed public spaces, such as Piazza San Marco in Venice, or public companies.
Regulation	Regulation represents a government's right to implement standards and rules to keep people safe, so long as these regulations do not impede on citizens' rights.
Incentives and Disincentives	Incentives and disincentives involve offering rewards or punishment for certain activities or actions. For instance, the government might decide to give discount vouchers to visitors who stay in a city for an extended duration to encourage overnight tourists.
The Establishment and Apportionment of Legal Rights and their Enforcement	The legal rights tool has to do with the government right to declare legal rights and monitor and enforce penalties for violations.
Information	Information involves the government spreading information on public issues amongst people or industries and advising that they act on these issues.
Mitigation and Compensation	Mitigation and compensation involves mitigating the consequences of municipal actions (for example, if a tourist cap should harm hotels) and compensating those affected by them.

[34] Ibid

Different tourism management proposals are going to leverage tools of government in different ways. The city must decide which tools of government are going to be the most appropriate, effective, and economically feasible in dealing with the problem of tourism. From there, it can decide which tourism management proposals are going to best fit the city's needs. The government organization with the biggest stake in this is Venice's Soprintendenza. The Soprintendenza is an administrative body with control over how the city's culture and history are treated. Due to the huge number of culturally and historically significant sites in Venice, the Soprintendenza has a great deal of control over the tools the city can use to manage tourism and preserve the historic integrity of the city.

2.5.2 Methods of Accessing Venice

Another key point that needs to be kept in mind when choosing a tourism management solution, especially one that regulates how many people can enter the city, is how tourists get into Venice. The city has a plethora of access points and methods of transportation for entering the city. These access points can be seen in Table 2.2. All of these points of access must be considered when determining how the city should regulate the flow of tourists into Venice.

Table 2.2 Ways tourists enter Venice

Form of Access	Location	Description
Air	Marco Polo Airport	Venice's airport receives visitors from all over the world. This is where many of the city's overnight visitors arrive on the mainland. From there, they take a bus, water bus (the Alilaguna), or water taxi into the historic city.
Train	Santa Lucia Train Station	Trains travel into the city over Ponte della Liberta. Venice's one train station, Santa Lucia, receives a mix of commuters, overnight visitors, and daytrippers on both regional and long-haul rail lines.
Car	Piazzale Roma or Tronchetto	Many of Venice's visitors arrive by car over Ponte della Liberta. However, since vehicles are not allowed in the historic city, tourists park their cars either in Piazzale Roma or on Tronchetto, then move into the city on foot or using public transport.
Private Coach Bus	Piazzale Roma	These buses are usually run by tour operating companies and bring large groups of daytrippers to the city for short shopping trips and guided tours. They arrive in Piazzale Roma over Ponte della Liberta.
Public Bus	Bus station in Piazzale Roma	There are several public bus lines that come into the city over Ponte della Liberta and arrive at the bus station in Piazzale Roma. These carry a mix of overnight and daytripper tourists from the area around Venice.
Cruise Ship	Tronchetto	It is very common for cruise ships in the Adriatic sea to stop in Venice. These bring huge groups of daytripper tourists who get off the ship all at once in the morning, then leave again in the late afternoon.
Boat	Various docks around the city	As Venice is an island city, it is fairly common for tourists to arrive via private boats that dock in various places around the city.

2.5.3 Maximum Occupancy

In order to effectively manage tourism, the maximum occupancy of historic Venice must be known. One way to obtain such a maximum occupancy is to consider what number of occupants in the city would cause the city to become unsafe in the event of an emergency evacuation. During emergencies, exits can become quickly overrun by congestion. Figure 2.10 clearly demonstrates bridge congestion where a large crowd has almost completely blocked Ponte della Paglia. In a scenario like this, if a sudden evacuation were to occur, people could be seriously injured or killed by being trampled.

Figure 2.10 Congestion on Ponte della Paglia

A recent example of this occurred during an Islamic ritual in Mecca, killing more than 2400 people.[35] A stampede was caused by a surge of pilgrims en route to a site of a religious ceremony when several people fell. As panic ensued, people trying to exit the grounds lead to an uncontrollable wave of people. The stampede involved 2-3 million visitors[36] traveling to Mecca, which is twice the resident population of the city. In comparison, the number of tourists in Venice can also double the resident population of the city.[37]

[35] "Hajj stampede: Saudi officials clarify toll after questions."
[36] Ibid
[37] Blanco et al, p.13

The maximum occupancy of a city can be related to the maximum occupancy rating for buildings. Just like stadiums and theaters, Venice's constituent islands can also be described as a bounded space with only so many exits (bridges and boats) and passageways. Maximum occupancy ratings for buildings are based on the size of the enclosed space and the number and dimensions of exits available, as well as the ability of people to move through those exits in a specific amount of time. There are several organizations that provide safety codes for building new stadiums and similar structures. The International Code Council and the European Committee for Standardization are two examples, and they use formulas to determine maximum occupancy rates for buildings as described in *Guide to Safety at Sports Grounds.*[38] These standards, described further in Chapter 3, were used in this project to determine the maximum occupancy of Venice.

2.6 Previous Strategies for Studying Tourism and its Effects

In addition to utilizing international safety codes for determining maximum occupancy, this project relied on previous studies of tourism and its effects on Venice. The organizations and publications referenced below were used extensively throughout the project. The most important of these were databases and studies on tourism published by Worcester Polytechnic Institute's VPC, the city's 2014 Annuario del Turismo and 2009 COSES report, and publications by expert Jan Van der Borg.

The VPC has collected a great deal of information on tourism in Venice, which is continuously displayed on a website. The"Venice Dashboard," shown in Figure 2.11, is a live online information hub documenting data on subjects such as current weather, hotel availability, and number of tourist arrivals. In this way, the Venice Dashboard is a helpful tool for accessing and helping to visualize information on tourism in Venice.

[38] *Guide to Safety at Sports Grounds 5th Edition*

Figure 2.11 The current Venice Dashboard[39]

The government of Venice also recognizes the need to study tourism. As such, the city government regularly commissions reports on tourism and funds initiatives to research tourism in historic Venice.

The Annuario del Turismo is a yearly report, the most recent of which was published in 2015 based on 2014 data, regarding the status of the tourism industry in Venice. It contains data on subjects such as overnight stays in all hotels, public transportation use, and access to the city. Economic information on the tourism industry, tourists arriving by cruise ship, airport arrivals, and data on public transport use are also provided.[40] While this document examines the

[39] "Venice Dashboard," Venice Project Center
[40] Mar, et. al, *Annuario del Turismo 2014*

economics of tourism in detail, it lacks substantial information on daytripper tourists. For instance, the Annuario lacks data on the number of tourists arriving by train, boat, and private tour buses from the area around the city.

COSES, or Consortium for Research and Educational Training, was a research group funded by the city. In 2009, the organization released a report analyzing the effects of both overnight and daytripper tourists. The document identified areas of concern such as bottlenecks and overcrowding in specific areas of the city. Additionally, the report estimated the number of daytrippers present in the historic city in 2007 to be 15,211,000, using an extrapolation from available data from the transportation industry.[41] To deal with the large number of tourists, COSES proposed that a cap be put on the occupancy of certain areas of the city, such as 30,000 people in the area between the Rialto Bridge and Piazza San Marco.

Jan Van der Borg, a Ph.D. in economics, has held the position of president of the Master and Bachelor courses in Tourism Research at the University Ca' Foscari of Venice and has proposed plans for sustainable tourism. He has numerous publications, including *Un modello lineare per la programmazione del turismo* and an article in *Crescita Turismo*, addressing unsustainable tourism in the historic city.[42] Van der Borg has hypothesized that the city should only allow 20,750 tourists a day, with a maximum capacity of 12 million per year.[43] He has stated, "[Venice] should reduce the influx of approximately 10 million annual visitors."[44] However, Van der Borg's numbers are outdated and were not calculated based on safety, but rather comfortability. This was done based on the idea that all tourists want to visit Basilica San Marco. Van der Borg hypothesized that a comfortable occupancy for San Marco would involve the following parameters: a flow rate of no more than 500 people per 20 minutes into the church, with a max occupancy of 15,000 people in any given 10 hour period.[45] Combining these parameters with data sourced from COSES, Van der Borg built up a system of equations for occupancies in various parts of the city (such as hotels, public transport, and restaurants). He used a computer program to solve this system of equations and extrapolate these parameters out to the entire city to get his overall occupancy numbers.[46] Since an occupancy based on safety would be more easily justifiable, this leaves the door open for new work to be done in calculating Venice's occupancy.

[41] Scaramuzzi et al, p. 19-20, 25
[42] Van der Borg and Costa
[43] "Resounding study of Venice: 10 million tourists too"
[44] Ibid
[45] Van der Borg and Costa, p.24
[46] Van der Borg and Costa, p.23

While a great deal of work has been done in analyzing tourism in Venice, counts need to be updated, and standards based on expert formulas considering safety impacts need to be taken into account, as previous work has never before studied tourism with safety as a main priority. By taking advantage of the information available in previous publications and studying existing tourism management proposals, the team built a better understanding of tourism in Venice. Moreover, the group constructed a robust tourism management plan that accounts for economic benefit and legality, while limiting the number of tourists in the city based on safety in the event of an evacuation.

3. Methodology

This project is intended to help the city of Venice reduce the negative impacts of tourism while promoting safety and prosperity. The group set forth the following objectives in an effort to fulfill the mission:

1. Determine and display the current occupancy of Venice.
2. Establish a maximum sustainable occupancy for the city in the case of an evacuation.
3. Evaluate existing tourism management proposals.
4. Propose a tourism management solution by combining aspects from the evaluated tourism proposals and incorporating a maximum occupancy based on safety.

The scope of this work includes the historic city of Venice, as seen in Figure 3.1, and not the entire municipality of Venice or the lagoon islands. Data collection was limited by the team's study period on site, which was from October 25th to December 18th 2015. Since this time period was outside the peak tourism season, the data collected during this period represents only a limited view of tourism in Venice and likely underrepresents the average number of tourists in the city at other times of the year. Thus, our final conclusions should be viewed in light of a best-case scenario.

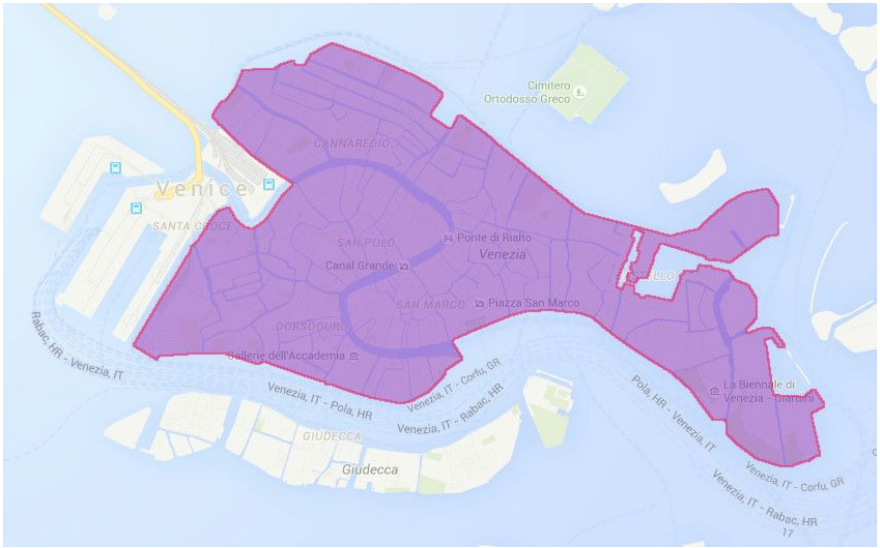


Figure 3.1 Map of the historic city of Venice

3.1 Determining and Displaying the Current Occupancy of Venice

In order to properly understand tourism in Venice, the team analyzed the different types of people that make up the city's current occupancy: residents, commuters, daytripper tourists, and overnight tourists. These occupancy numbers were determined both island by island and for the historic city as a whole. Moreover, the team realized that it would be useful to display specific information on tourists on a daily basis, so others might have continuously updated data. For this purpose, the team built widgets on the Venice Dashboard to display arrivals by train, information about the occupancy of AirBnB's, and the overall daily presence of tourists in the city. These were meant to help provide a more complete picture of many how tourists come into the city each day and where they stay at night; information that could be useful in predictive models of pedestrian mobility.

3.1.1 Determining the Current Occupancy

Residents:

The current occupancy of residents in the historic city of Venice is constantly monitored by the city government and displayed on the Venice Dashboard. According to the Dashboard, the resident population of Venice was 55,700 at the beginning of December 2015.[47] To aid in population analysis, the group also utilized the 2011 Italian Census. While the Venice Dashboard had more updated figures for the resident population of the city as a whole, the census allowed the group to determine the population of each individual island in Venice.

Commuters:

To determine the number of people commuting into and out of Venice, the team again made use of the 2011 Italian Census, which has information about the number of commuters that go into and out of various areas within the city. The team used this information to calculate the number of people working in certain islands in the city. However, the census lacked information about exactly how many commuters come into Venice every day from areas outside the city. In order to estimate how many commuters enter the city every day, the team took counts of people arriving in the city by train. Previously, the only good source of train ridership information was the COSES report from six years ago. The group decided that the best way to update the daily arrivals by train would be by conducting counts of train passengers arriving in the morning at Santa Lucia, Venice's train station (the location of which can be seen in Figure 3.2). This count also helped the team get a better idea about the number of commuters and tourists entering Venice every day, as previously train arrival data was all based on estimates.

[47] "Mappa della Popolazione"

The team used hand clickers to count the number of daytrippers, overnighters, and commuters arriving at the station in the morning and early afternoon.

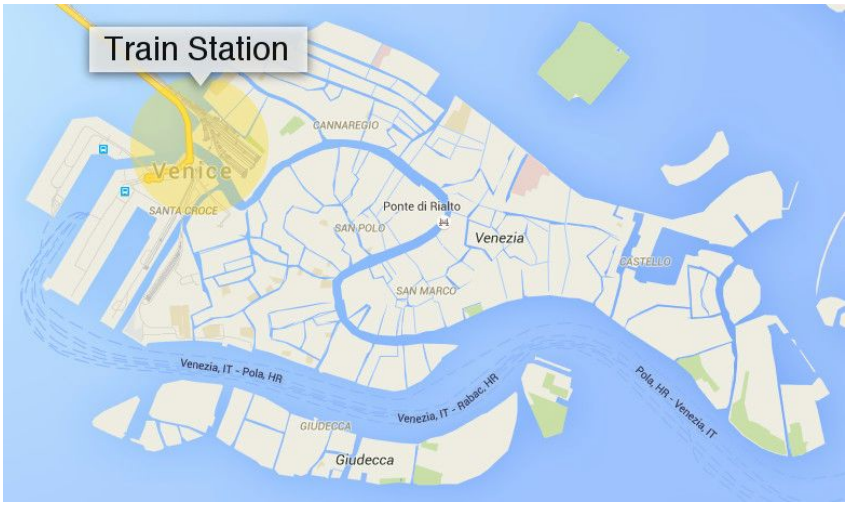


Figure 3.2 The location of Santa Lucia train station

The counts at the train station were done with all four members of the team. One team member was responsible for counting the overall number of people disembarking each train, the second member counted daytrippers, the third team member counted overnight tourists, and the final team member kept track of the when each train was arriving and which platforms the team had to be at for each arrival. The number of commuters was determined by simply taking the difference between the total arrivals and the number of tourists.

For each train, the team stood at the end of the platform so as to get a good view of each passenger disembarking. From this position, the team was able to determine which type of passenger each person was. Commuters usually disembarked first, were typically alone, seemed to be in a rush, were dressed nicely for work or school, and were often wearing headphones. Overnight tourists were typically in small, family sized groups and had luggage. Meanwhile, daytrippers were typically in small groups (or very large tour groups), seemed slightly lost in the train station, and were often dressed for walking around.

While counting train arrivals, the team wanted to validate that tourists and commuters were being distinguished correctly from one another. Therefore, the team identified 35 people getting off the trains, determined whether they were tourists or commuters, then validated the determinations by asking the train riders whether they were tourists or not. The team found that only 3 out of 35 people had been misidentified, netting an accuracy rating of 91%.

Overnighters:

The most recent data for overnight tourists at the time of this project was from the 2014 Annuario del Turismo. Using this document, the team was able to obtain an accurate value for the number of overnighters in the city. However, the Annuario does not precisely breakdown overnighters by island. In order to get an estimate for the number of overnighters living in each island, the group used hotel data from 2008 collected by the VPC.

Daytrippers:

The number of daytrippers in the city every day is a point of some contention in Venice. Since daytrippers are fairly difficult to keep accurate track of, there is little reliable information about them. The only really solid estimate of daytrippers was in the 2009 COSES report using data from 2007. In this report, COSES surveyed a number of tourists in Piazza San Marco[48] to estimate the real number of daytrippers for the year. The team used this estimate as a starting point and assumed that the number of daytrippers in the city had grown year-over-year at the same rate as overnighters. Using a growth trend extrapolated from overnighter data in the 2014 Annuario del Turismo, the team obtained a real year-by-year percent change for overnighters, then applied this same percent change to the 2007 COSES estimate in order to estimate the number of daytrippers in the city in 2014. Mathematically, percent change can be defined as:

$$\%\ Change\ =\ (Final - Initial)/(Final) \quad \textbf{(1)}$$

Initial and Final represent the number of tourists per year for two separate years.

For instance, if there were 500,000 overnighters in 2007 and 1,000,000 in 2008, then the percent change would be:

(1,000,000-500,000)/(500,000) = 100 percent increase.

Now, say the amount of daytrippers in 2007 was 2,000,000:

(1,000,000-500,000)/(500,000) = (X-2,000,000)/(2,000,000)

One would simply solve for X to find the number of daytrippers in 2008. In this case, X=4,000,000, meaning that, following the same growth trend as overnighters, there would be 4,000,000 daytrippers in 2008. This process is then repeated for the desired future years.

[48] Scaramuzzi et al, p.25

3.1.2 Display the Current Occupancy

Fully conceptualizing the occupancy of a whole city can be difficult. This is especially true because tourist and commuter arrivals constantly change throughout the year. Therefore, in order to help visualize how people get into the city every day, the team made use of the Venice Dashboard, which displays the occupancy of Venice every day. In order to improve the Dashboard, the team built widgets related to train arrivals, AirBnB stays, and daily tourist presence.

In order to build this train widget, the team worked alongside Paolo Corposanto, a Venetian train expert. Paolo provided the team with an in-depth spreadsheet about train arrivals in Santa Lucia (i.e. arrival times, capacity, expected percent occupancy). See Appendix F for this spreadsheet. Using the data, the group can calculate the total number of people who arrive by a certain time in the day by summing the occupancies of the trains up to that time. The occupancy is calculated by multiplying the expected percent occupancy by the capacity.

$$occupany_{train} = \%\ occupancyy_{train} \times capacity_{train} \textbf{ (2)}$$

$$total\ arrivals = \sum_{t=0}^{trains} occupancyy_t \textbf{ (3)}$$

Since train arrivals represent a large number of people coming into the city, it was important that the calculated number was as accurate as possible. The percent occupancy in the spreadsheet is only an estimate. To achieve a more accurate occupancy the group engaged in a train count process for different days of the week, as described above. In this process the group counted and separated people arriving on each train at Santa Lucia into one of three groups: commuter, daytripper, and overnighter. This gave the group true arrival data as well as arrival distributions for commuters, daytrippers, and overnighters.

While the train counts did help us adjust the accuracy of the occupancy estimates of each train, they were still only reflective of the month of the year we performed the counts, November. Tourist arrivals change from month to month as is shown in the COSES report and Annuario del Turismo. Therefore, it was important to weight the total arrivals based on which month of the year it is. The weight for a given month would be the ratio of tourist arrivals for that month to the tourist arrivals for November.

$$weight_{month} = arrivals_{month} / arrivals_{november} \textbf{ (4)}$$

$$weighted\ total\ arrivals = total\ arrivals \times weight_{month} \textbf{ (5)}$$

These weighted data are displayed on the train widget of the Venice Dashboard.

Another area the group needed to update was the information regarding hotel bookings. Recently, the Venice Project Center gained access to AirBnB hotel listings and booking information. Hotels and bed and breakfasts combined represent the maximum overnight tourist occupancy of the city. By adding the number of occupied beds for both bed and breakfasts and hotels, the total number of overnighters everyday can be estimated. To make the information accessible to the public, the group linked the AirBnB data to the already existing hotel widget on the Venice Dashboard.

Finally, the team added a new tourist presence widget to the Dashboard. This widget shows the total number of tourists in the city and generates a graph of the presence of tourists throughout the day. For visual comparison, the widget also graphs a line representing the number of residents in the city. The widget sources its numbers from the existing tourist arrivals and resident presence widgets.

In order to provide access to tourism data in an easy-to-read format, the team relied on the VPC's online Venice Dashboard. For this project, the team identified several areas where the Venice Dashboard could be improved to show more accurate and detailed information about tourism in Venice. As such, the team redesigned the Dashboard to be more visually appealing and better organized. This new dashboard included updated versions of all of the existing widgets, as well as the new train arrival widget, Airbnb widget, and presence widget. A mockup of the new dashboard can be found in Figure 3.3.

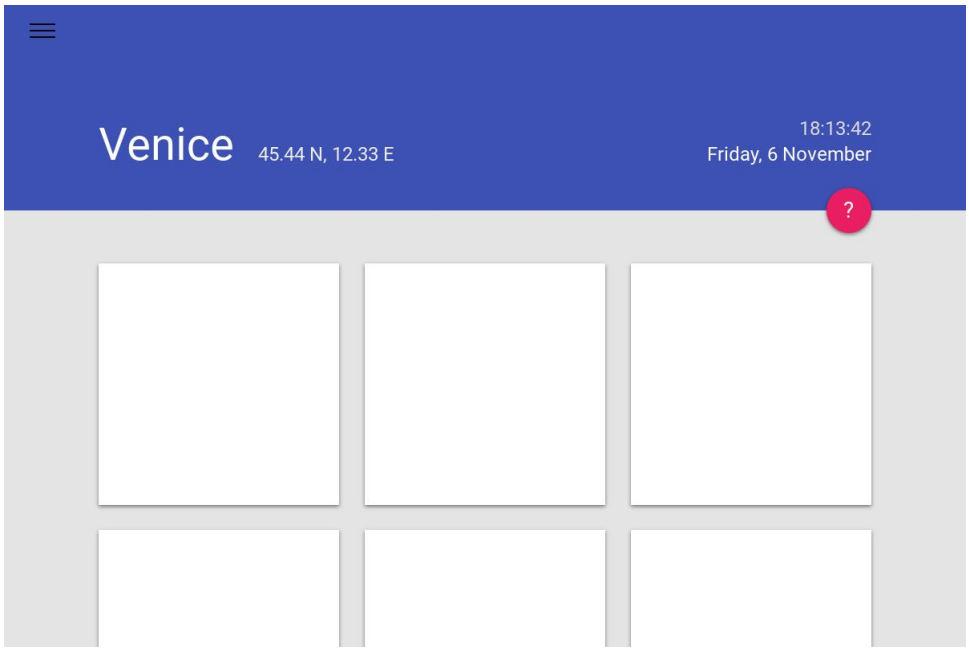


Figure 3.3 Tourism dashboard design mockup using Material Design

3.2 Determining the Maximum Sustainable Occupancy of Venice

As discussed in the background section, a maximum occupancy of Venice has been proposed before, in studies by Jan Van der Borg and COSES, but never based on safety concerns in the event of an evacuation. This project set out to do just that.

In order to determine the max occupancy of Venice based on safety concerns, the group decided to compare individual islands in Venice to sports stadiums, since they both have limited means of egress and are similar in size. Making this comparison also allowed the group to apply stadium evacuation codes to Venice.

International safety codes for evacuating a stadium or standing assembly were taken from the *Guide to Safety at Sports Grounds*[49], which sites the European Committee for Standardization. The guide specified that a complete evacuation of a stadium should take no more than eight minutes, as after that length of time, panic can ensue, and that 66 people should be able to evacuate per minute per meter of stepped egress.[50] These safety parameters are visualized in Figure 3.4.

[49] *Guide to Safety at Sports Grounds 5th Edition*. Department for Culture, Media and Sport, 2008.
[50] *Guide to Safety at Sports Grounds 5th Edition,* p. 21

Figure 3.4 Safety Parameters Visualized

Using these parameters, the team was able to formulate an equation for the number of people that can safely evacuate from a stadium. Theses parameters are realized in equation **(6)**

$$Safe\ Occupancy = (flow\ rate) * (time) * (width\ of\ egress) \quad \textbf{(6)}$$

$$Safe\ Occupancy = 66\ \frac{people}{m*min} * 8\ min * (width\ of\ egress)$$

So, the key parameter needed to calculate the safe occupancy of an area is the width of all egress points off of that area. For example, say an area has an egress point with a width of 2 meters. To find the number of people able to safely evacuate through this point within the safe 8 minute limit, one must multiply **66** (people/m*min) * (**8** min) * (**2** m). The result is **1056** people.

In order to apply this safe occupancy equation to Venice, the team looked for a key area of high occupancy and congestion. In its 2009 report, COSES did a lot of work to determine the occupancy of Venice. More specifically, the report identifies areas of high congestion. Figure 3.5 shows areas of bottle-necking, where large crowds of people clog roads and bridges.

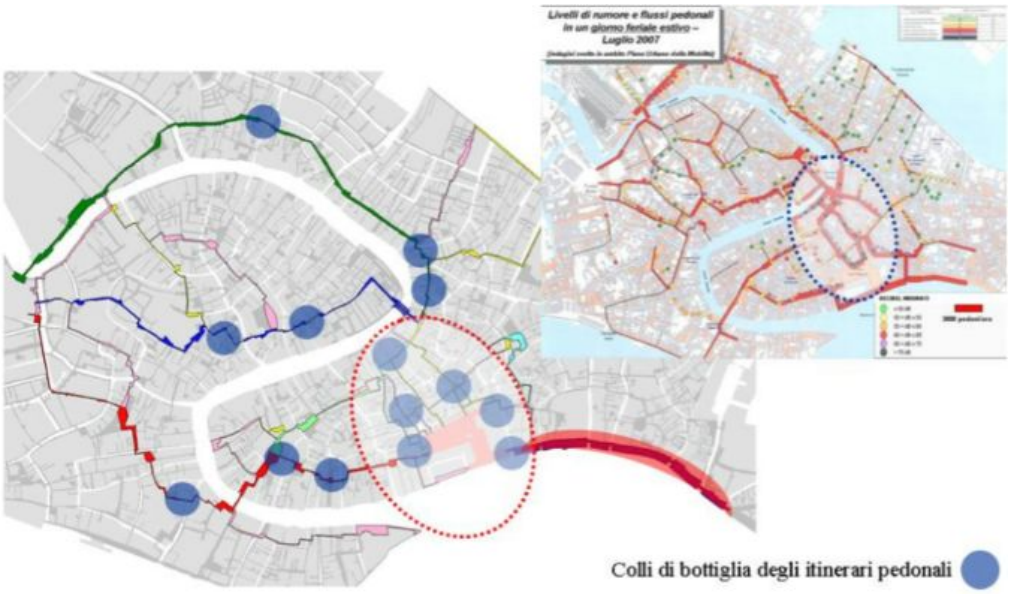


Figure 3.5 Areas of highest congestion in Venice[51]

The enclosed dotted area in Figure 3.5 represents the greatest concentration of bottlenecks in Venice. These bottlenecks are caused by a large number of very narrowing streets that confine pedestrian movement. The identified area is in the sestiere of San Marco between the Rialto Bridge and Piazza San Marco. It is comprised of five smaller islands: San Marco, San Gallo, Giardinetti Reali, San Luca, and San Bortolomio. This collection of islands receives the highest congestive traffic out of the whole historic city. Therefore, this area is where a maximum occupancy would be the most relevant in the case of an emergency evacuation. The team made the assumption, owing to personal observation, colloquial belief among native Venetians, and comments made by Van der Borg in his research[52], that all daytripper tourists will go through this area at some point during the day. This assumption is additionally supported by the fact this area contains the largest attractors, by far, for tourists in the city[53]. In this way, the team deduced it be the best area to focus on for an analysis of maximum occupancy. From now on, this area will be referred to as the "green area," as shown in Figure 3.6.

[51] Scaramuzzi et al, p.107
[52] "Un modello lineare per la programmazione del turismo," p.23
[53] Flaxington et. al.

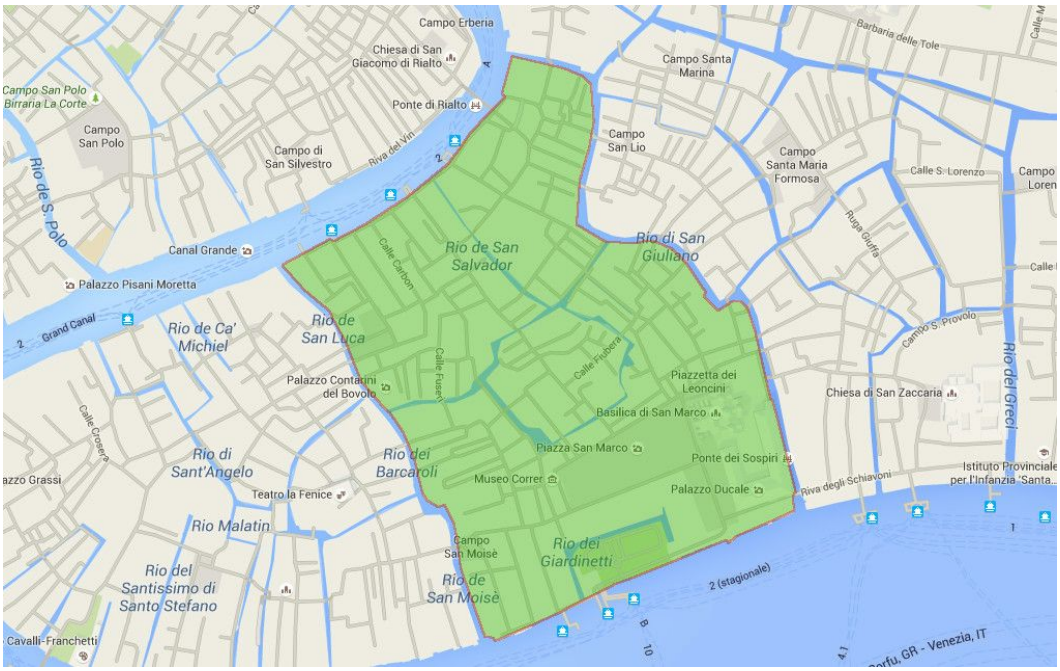


Figure 3.6 The area of analysis for occupancy (green area)

In the case of the green area, the parameter for stepped egress width is relevant to all the bridges leading out of the area because bridges require people to both ascend and descend steps. The green area treated as a stadium with multiple egress points is visualized in Figure 3.7.

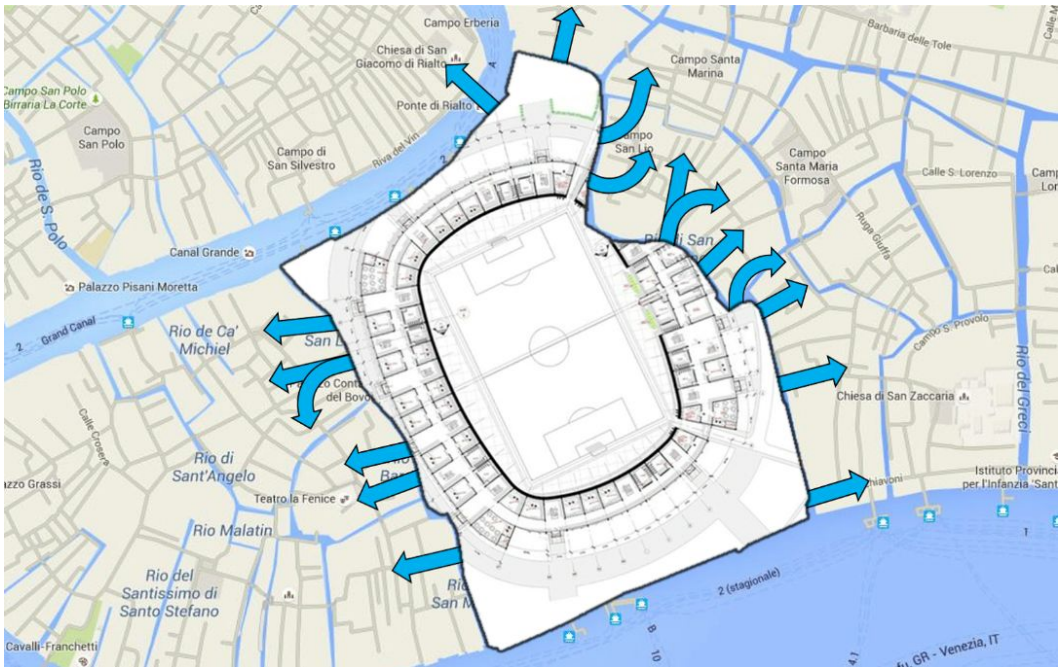


Figure 3.7 Visualization of the green area treated as a stadium

In order to utilize equation **(6)** to determine the green area's maximum occupancy, the team had to measure the widths of the bridges out of the green area. We chose the narrowest point of each bridge since bottlenecking would occur at these points. The narrowest, or "limiting" bridge width is portrayed in Figure 3.8.

Figure 3.8 The maximum width of a bridge and the limiting width

Bridges are not the only form of egress out of the green area. Boats can move people in and out. However, public boat stops were not considered in the team's calculations, as boats would not be a reliable form of egress in the case of a hasty evacuation. Relative to the number of people that would need to leave the green area within the eight minute limit, the number of boats available would be insignificant. At most, there would be one or two boats stopping at the docks during the eight minute evacuation window. Considering that the average ACTV waterbus capacity is 230 people[54], this means that, at best, public boats could be counted on to ferry a maximum of 460 people out of the green area, if they were empty on arrival and if the boat operators decided to stop in an uncertain and dangerous situation. Even in this best case scenario, this number is insignificant compared to the total evacuation. As a result, boat stops were disregarded in the team's calculations and bridges were considered are the only viable way out of the green area in an evacuation. Figure 3.9 shows all the bridges leaving the green area.

[54] "FAQ"

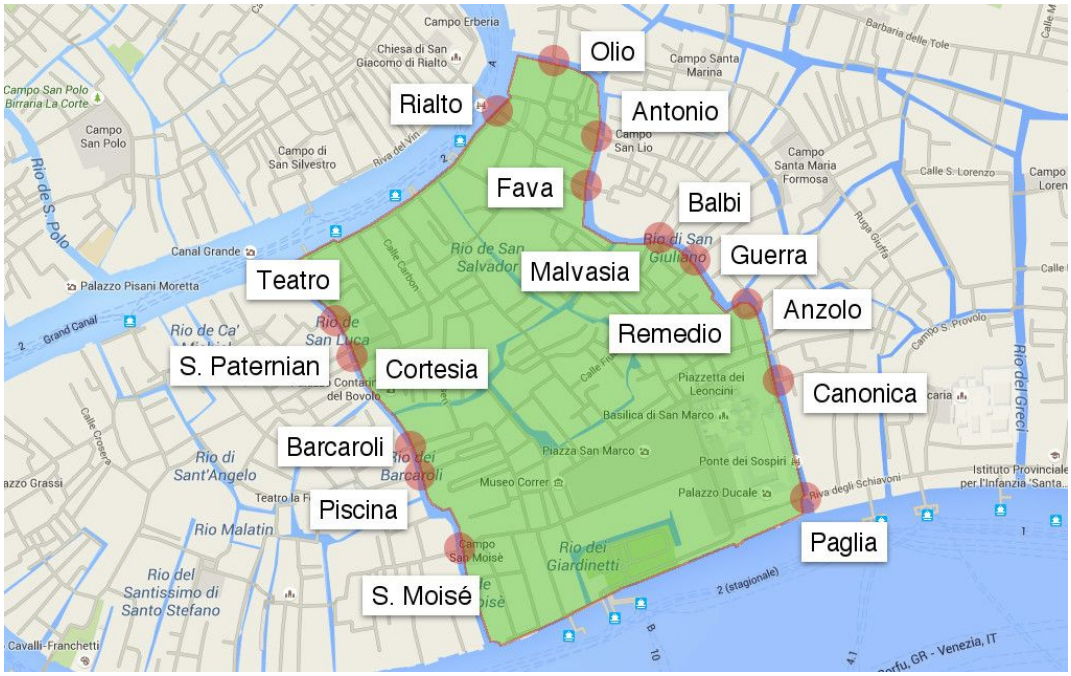


Figure 3.9 Modes of egress from the green area

The team then applied the width of each bridge to equation **(6)** to find the maximum number of people that could be leave the green area over each bridge during an evacuation, which is described in equation **(7)**

$$Individual\ Egress\ Occupancy = (Bridge\ Width) * (66\ people/min/meter) * (8\ min) \quad \textbf{(7)}$$

Added together, these values represented the maximum occupancy of the entire green area at any point during the day, as shown in equation **(8)**

$$Maximum\ Occupancy = \sum_{i=0}^{n} (individual\ egress\ occupancy),\ n = number\ of\ bridges \quad \textbf{(8)}$$

This daily value was then converted to a maximum yearly occupancy of the green area by multiplying by the number of days in a year.

The total occupancy of the green area is equal to the sum of the number of residents, commuters, overnighters, and daytrippers. This yields the total occupancy in equation **(9)**

$$Occupancy = residents + commuters + overnighters + daytrippers \quad \textbf{(9)}$$

Therefore, the maximum safe occupancy obtained above must be composed of some number of residents, commuters, overnighters, and daytrippers. The number of residents and commuters in the area can be taken as constants, as these people need to be in the area. So, the variables in this equation are only the two types of tourists. However, from previous research by the VPC, the team knew that daytrippers are not nearly as beneficial to the city's economy as overnighters.[55] An IQP, relating to Venice's tourism, published last year calculated that one overnighter is equivalent to 6.5 daytrippers.[56] This means that, to keep the population of the green area under the maximum occupancy threshold, the value that would be best to reduce is the number of daytrippers. Knowing this, the team took the number of overnighters as another constant and built equation **(10)** to determine the maximum allowable number of daytrippers in the green area.

$$\textit{Max Daytrippers} = \textit{(Safe Occupancy)} - \textit{(estimated \# of overnighters in green area)} - \textit{(estimated \# of residents in green area)} - \textit{(estimated \# of commuters in green area)} \quad \textbf{(10)}$$

In order to determine the number of overnighters in the green area, the group used data from the VPC that listed the number of beds per island, as determined in Objective 1. Summing the number of beds for the five islands of the green area yielded the maximum number of overnighters staying in the green area. In addition, the team had to factor in the number of overnighters who did not stay in the green area, but were likely to visit. This was obtained using the assumption that an overnighter will visit the green area one day during his or her total stay. Therefore, the number of overnighters in the area would be the overnighters living there, plus a fraction of the rest of the overnighters in the city determined by their average stay in the city, which is 2.33 days.[57] This calculation is described in equation **(11)**

$$\text{estimated \# of overnighters in green area} = (\textit{total \# of overnighters} - \textit{\# of beds in green area})/2.33 + \textit{\# of beds in green area} \quad \textbf{(11)}$$

The number of residents was calculated by summing the resident populations of the individual islands in the green area, as determined in Objective 1.

A similar process was used to determine the number of commuters in the green area. The census lists the number of commuters into and out of Venice by areas of the city. To get the number of commuters in the green area, the team took the number of commuters into the green area from each census tract within it, then subtracted the number of people who commute out of those same census tracts.

[55] Impacts of Tourism: Analyzing the Impacts of Tourism on the City of Venice, p.36.
[56] Ibid
[57] Mar, et. al, *Annuario del Turismo 2014,* p.14

Plugging all of these values into equation **(10)**, the team determined the maximum allowable number of daytrippers in the green area.

The next step in determining the sustainable occupancy of the city was to take the occupancy of the green area and apply that information to the city as a whole. This was done using the team's key assumption that the green area is the most popular tourist area in Venice and that all tourists want to visit some portion of this area at least once during their stay. Therefore, the maximum occupancy of the green area can be said to limit the occupancy of the city as a whole. This is because, owing to the popularity of the green area amongst tourists, a safe occupancy of the city must allow all daytrippers in the city to visit the green area at some point during the day. These concepts were boiled down in equation **(12)**, which gives the maximum allowable number of tourists in the city per year.

$$Tourist\ Cap = Max\ Daytrippers\ +\ total\ \#\ of\ overnighters \quad \textbf{(12)}$$

Max Daytrippers is calculated in equation **(10)** and the total number of overnighters was taken from the 2014 Annuario del Turismo.

As this value for daytrippers was lower than the number of daytrippers that currently visit Venice, the team went on to find the percent reduction of daytrippers needed to satisfy the new maximum occupancy. This calculation can be found in equation **(13)**.

$$Percent\ Daytripper\ Decrease\ =\ \frac{2014\ \#\ of\ daytrippers - Max\ Daytrippers}{2014\ \#\ of\ daytrippers} \quad \textbf{(13)}$$

From this yearly value, the team calculated an average number of allowable tourists in Venice per day by dividing by 365 days per year. It is important to note that the number of daily daytrippers would not be an absolute number, but instead be a function of the number of daily overnighters in the city, as well. If there were more overnighters in the city, less daytrippers would be able to fit in safely as a result. Conversely, if on any given day, all of Venice's hotels are not full, there would be less overnighters, so more daytrippers could be let into the city. Equation **(14)** shows this calculation.

$$\#\ of\ Daily\ Daytrippers = Tourist\ Cap - \#\ of\ Daily\ Overnighters \quad \textbf{(14)}$$

The calculations used in this project assume each bridge out of the green area will be optimally used by people evacuating. In reality, people are more likely to attempt to evacuate over more popular bridges. In this way, the team's conclusions should be viewed as a best-case scenario, as the unequal use of bridges in a real-world evacuation would cause additional

bottlenecking, therefore lowering the overall safe occupancy of the green area. A future analysis should look to count the actual flow of people off of each bridge in the green area in order to determine the popularity of each bridge. The team only had enough time to do a bridge count for one island, San Bortolomio, the data for which is in Appendix K. A member of the VPC stood at each bridge off this island and counted people entering and leaving. While this count did not provide all the data needed to determine the popularity of each bridge in the green area, it did prove that major bridges like Rialto are used by a much higher proportion of people than smaller bridges are.

Overall, the team calculated a maximum occupancy for Venice by examining the most densely populated region of the city. Moreover, the reduction in tourism that this maximum occupancy necessitates will minimize harm to the city's economy, as this proposal only limits daytrippers, who are responsible for very little of the tourism industry's revenue compared to overnighters. Should this new maximum occupancy be adopted, tourism in Venice will not only be safer in the event of an evacuation, but also tourism will be more sustainable, as the lack of huge crowds of tourists would make the daily lives of the city's permanent residents much easier.

3.3 Evaluating Existing Tourism Management Proposals

Each tourism management proposal relies on different methods to control the number of tourists in Venice. As a result, they each have their own specific pros and cons. The team weighed the various aspects of each proposal in order to identify strengths and weaknesses. Specifically, the team analyzed five proposals: Pass4Venice, S. Marco Pass, Venezia Libera, Ven-us (by Italia Nostra), and ZTL Revolution. While there are various other extant tourism management proposals out there, the team determined that these five were the most well-developed and all had particularly promising aspects to them. The team researched each proposal online, then invited proponents of each to the Venice Project Center to give a presentation. The minutes from each of these meetings can be found in Appendix A through Appendix E. These meetings provided an opportunity for proponents to clarify the key points of their proposals and for the team to ask important questions.

Pass4Venice: The team spoke to Andrea Casadei about Pass4Venice. This initiative focuses on controlling a certain number of predefined entry points, called hubs, to the city. Guests would register to enter historic Venice, paying a dynamic price that fluctuates depending on current demand.

S. Marco Pass: The speaker was Marco Scurati. This pass relies on the assumption that all tourists in Venice want to visit Piazza San Marco. As such, it focuses on limiting access to Piazza San Marco on the theory that regulating access to San Marco will de facto regulate access to the entire historic city.

Venezia Libera: Roberta Bartoloni spoke on behalf of her proposal, Venezia Libera, or Free Venice. This proposal would require visitors to make a free reservation to enter the city. In this way, Venezia Libera sets a hard cap for accessing Venice, but a visitor's ability to enter is not based on the ability to pay a ticket fee.

Ven-us: The speaker for Ven-us was Paolo Lanapoppi from Italia Nostra, an Italian conservation group. This proposal does not regulate tourism by controlling the access of individual tourists, but rather focuses on regulating the companies that bring large groups of daytrippers to the city. The proposal also includes allowances for tax credits to be used to encourage landlords in Venice to rent apartments to local residents rather than tourists, reducing lodging and therefore reducing the number of tourists.

ZTL Revolution: The team spoke to Cristiano Farina and Marco Bonaventure about ZTL Revolution. This proposal builds on the idea of ZTL's, or Limited Traffic Zones, which are already in effect in Italy and impose fines on drivers for entering certain restricted areas during certain times of the day. ZTL Revolution seeks to apply this idea to Venice, where daytripper tourists entering Venice by any means (such as bus, train, or Alilaguna boat) would be subject to an approximately 3 Euro tax. Since overnighters are already subject to a similar city tax for hotels, they would not pay an additional tax, but would instead receive incentives and vouchers for staying in the city overnight. In this way, the ZTL Revolution would attempt to encourage overnight stays in order to increase tourism revenue.

The team compared these different proposals based on the categories in Table 3.1. To compare all the proposals side-by-side, the team created a matrix (Figure 4.17) populated with information from each proposal.This allowed the team to see and compare the main goals and methods for managing tourism.

Table 3.1 Categories of Comparison for Tourism Management Proposals

Category	**Questions to Consider**
Tourist Cap	Does the proposal identify a numero chiuso (hard cap), a soft cap for the number of tourist in the city, or no cap at all?
Targeted Tourists	Which types of tourist does this proposal target? Does the pass make some distinction between daytrippers and overnighters?
Max Tourists per Day	How many tourists would be able to come into the city per day?
Area Covered	Which areas of the city are involved in the proposal?
Key Assumptions	What major assumptions about tourist behavior does the proposal make?
Requirements	What would a tourist have to do to adhere to the management plan?
Services	What services does the proposal offer to tourists?
Fee	How much would the pass or registration cost for a tourist?
Documentation	How would tourists be checked for adherence to the management plan? Is a physical pass required? What sort of format would the pass have? Digital, card, wristband, etc.
Validation	What mechanism would the city use to check tourists?
Physical Gates	Does the proposal require that physical gates or turnstiles be installed?
Cost to the City	If this proposal were implemented, how much would it cost the city?
Implementation Time	How long would it take to implement the proposal?
Presumed Benefits	In what way does the pass claim it will benefit the city?
Income for the City	Would the proposal generate revenue? If so, how much?

Next, the team sought to analyze these different proposals categorically. As such, the team built a second analysis matrix to evaluate the proposals against one another. The categories of analysis for this matrix are described in Table 3.2.

Table 3.2 Categories of Analysis for Tourism Management Proposals

Category	**Questions to Consider**
Economic Feasibility	Can the city afford it? Does it generate enough revenue to cover potential costs?
Logistical and Infrastructural Feasibility	Would the city be able to build and implement the infrastructure and services necessary?
Legality and Equity Concerns	Would this proposal unfairly favor certain groups? Is it allowable under Italian law?
Required Awareness Campaign	How much advertising would be required to properly implement the proposal?
Daytripper Limitation	Does this proposal do something to limit the number of daytrippers in the city?

Generally speaking, proposals that can be implemented quickly were considered stronger, since the problem of tourism in Venice is a pressing issue that should be addressed as quickly as possible. Additionally, proposals that minimize upfront costs and involve building less infrastructure were generally regarded as stronger because the team wanted to minimize the economic impact that tourism management has on the city. Proposals that have fewer legality and equity concerns attached to them are also stronger, as are those that would require less legal advocacy and campaigning to the public. Finally, since daytripper tourists cause most of the issues related to tourism in the city, proposals that do a better job at targeting daytrippers are stronger.

Using the team's descriptive matrix and the analysis of the five different solutions, the team identified the most important criteria of a good tourism management plan so that those criteria could be included in a new, hybrid tourism management proposal. These criteria included immediate action, gradual restrictions, reduction to a maximum occupancy, income generation, and a focus on daytrippers. All of these criteria were incorporated, in some form, into a new tourism management plan, helping us meet our fourth objective

3.4 Proposing a Hybrid Tourism Management Proposal

After considering the different aspects of the tourism management proposals and determining Venice's maximum occupancy, the team built its own hybrid tourism management proposal with a hard cap on tourism determined by safety concerns in the case of an evacuation. The key aspects of this proposal were determined from the team's analysis of the existing tourism management proposals. Additionally, the new proposal was laid out in stages, whereby certain components should be implemented either in the short, medium, or long term. This will allow the city to evaluate at each stage how well the tourism management solution is performing and what can be done to improve its implementation.

4. Results

This chapter presents the team's findings and analysis organized by objective.

4.1 Determining and Displaying the Current Occupancy of Venice

The occupancy of Venice consists of the total number of overnight tourists, daytripper tourists, commuters, and residents. Information regarding the residential population was provided by the Venice Dashboard, while that of overnighters was provided by both the 2014 and 2011 Annuario del Turismo. Commuter data was provided by the 2009 COSES report. Therefore, defining this occupancy was dependent solely on the number of daytrippers in the city. Daytripper numbers were calculated by data extrapolation. The assumption was made that overnighters and daytrippers grow by the same percent change each year, which is described in equation **(15).**

4.1.1 Determining the Occupancy of Venice

Daytripper numbers were calculated by data extrapolation. The assumption was made that overnighters and daytrippers grow by the same percent change each year, which is described in equation **(15).**

$$\%\ Change\ =\ (Final - Initial)/(Final) \quad \textbf{(15)}$$

The group acquired the number of overnighters each year, from 2007 to 2014, from both the 2014 and 2011 Annuario del Turismo. The 2009 COSES report provided the initial daytripper datum point for 2007. The team then used the percent change of the overnighters and applied it to the COSES datum point to achieve Figure 4.1.

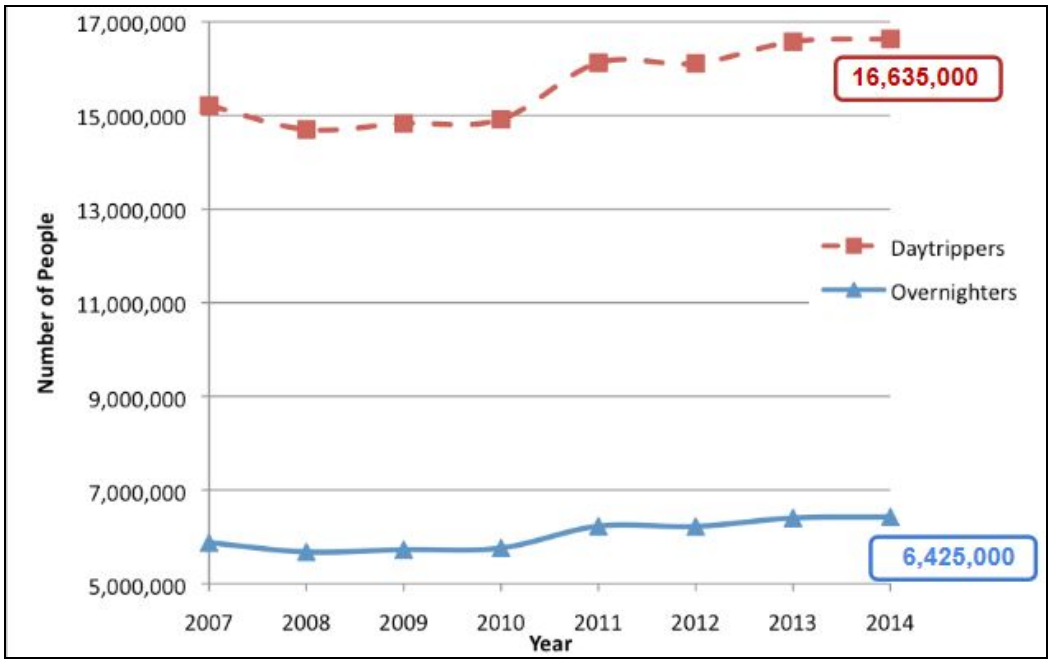


Figure 4.1 Daytripper Extrapolation

For example, COSES estimated the number for daytrippers for 2007 to be 15,211,000. The number for annual overnighters for 2007 and 2008, found in the Annuario, are 5,875,000 and 5,677,000, respectively. To find the 2008 daytripper population:

$$(5,677,000 - 5,875,000)/(5,677,000) = (x - 15,211,000)/(x)$$
$$(1.03487757618)(x) = 15,211,000$$
$$x = 14,698,357$$

In the end, the number of daytrippers in 2014 was close 16,635,000. To find the total yearly tourists for 2014, the team added the 2014 Annuario overnighter number, 6,425,000, with the 2014 daytripper extrapolation to get a number close to 23 million total tourists in 2014.

Figure 4.2 displays the average daily and annual number of tourists, commuters, and residents in Venice, based on our calculations.

	 Overnighters	 Daytrippers	 Commuters	 Residents
Daily	**17,600**	**45,580**	**22,700**	**55,700**
Annual	**6,425,000**	**16,635,000**	**7,600,000**	**20,330,000**
Percentage	**12.6 %**	**32.6 %**	**14.9 %**	**39.9 %**

Figure 4.2 The Current Occupancy of Historic Venice

4.1.2 Displaying the Current Occupancy

As described in Chapter 3, section 1, the team performed two days worth of counts at Santa Lucia train station, one on a weekday and the other on a weekend day. This data appears in Appendices I and J and was used to calculate hourly percent occupancy trends. Figures 4.3 through 4.6 show this data. The x-axis defines the hour of the day. The y-axis presents the percent of arriving commuters, overnighters, and daytrippers. This was calculated by dividing the number of commuters or daytrippers by the total occupancy of the train. A trend line was not built for overnighters, as large groups of overnighters tend to arrive on certain trains, meaning that their arrivals do not lend themselves to an hour-by-hour trend. Seen below, Figures 4.3 and 4.4 represent a weekday count while Figures 4.5 and 4.6 represent a weekend day count. A best-fit trendline was used to predict arrival percentages at any time between the time frame of the x-axis. This trendline is described as a function y(x) below each graph.

Figure 4.3 describes a count from 7:30 to 12:00. This figure shows that weekday commuter numbers are only significant before 9:30, after which they slowly diminish below 20 percent.

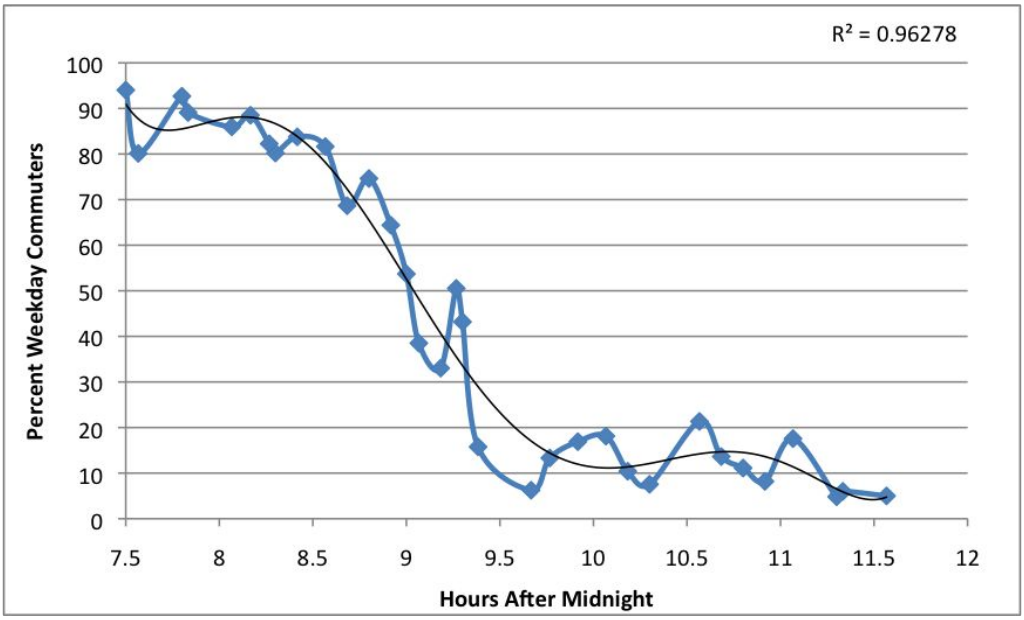


Figure 4.3 Percent of weekday train riders that are commuters by time of day

For reference, the polynomial describing this trend line is:

$$y(x) = (2.1439)x^6 - (123.87)x^5 + (2,964.6)x^4 - (37,616)x^3 + (266,829)x^2 - (1 * 10^6)x + (2 * 10^6)$$

The next step was to determine the percent of arriving daytrippers. Figure 4.4 describes the daytripper count from 7:30 to 12:00, after which the team applied functional symmetry to achieve a bell curve, assuming that the percent occupancy of daytrippers would diminish at the same rate as it grew. The team deduced that this would be a valid assumption since the curve reached a maximum at 11:34.

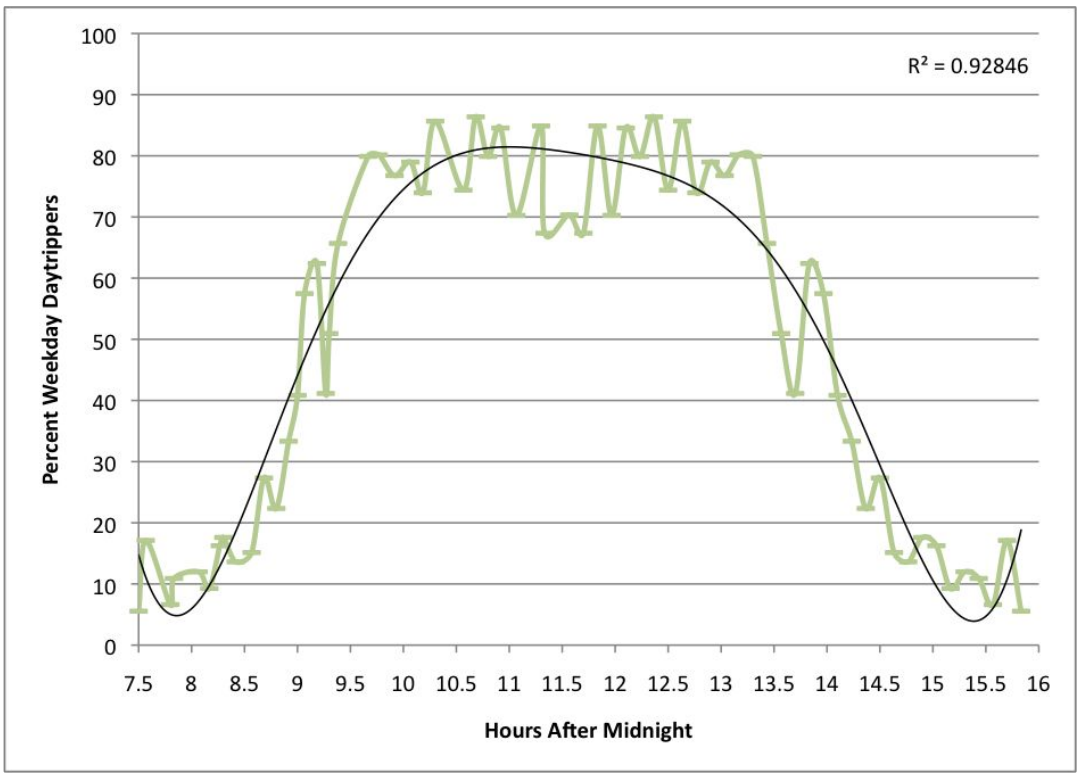


Figure 4.4 Percent of weekday train riders that are daytrippers by time of day

For reference, the polynomial describing this trend line is:
$y'(x) = (0.0476)x^6 - (3.3308)x^5 + (96.187)x^4 - (1,466)x^3 + (12,426)x^2 - (55,463)x + (101,709)$

Figures 4.5 and 4.6 represent train counts performed on a weekend day, from 8:18 to 9:20. Figure 4.5 shows commuter arrivals, while 4.6 shows daytripper arrivals.

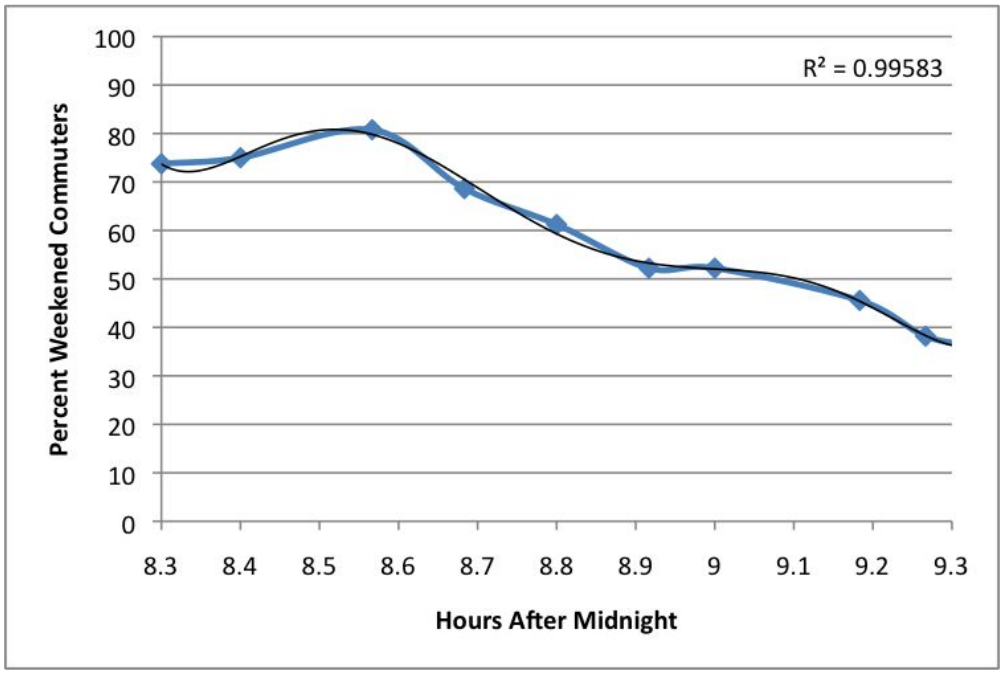


Figure 4.5 Percent of weekend train riders that are commuters by time of day

For reference, the polynomial describing this trend line is:

$$y''(x) = (4,541.5)x^6 - (240,728)x^5 + (5 * 10^6)x^4 - (6 * 10^7)x^3 + (4E + 08)x^2 - (1 * 10^9)x + (2 * 10^9)$$

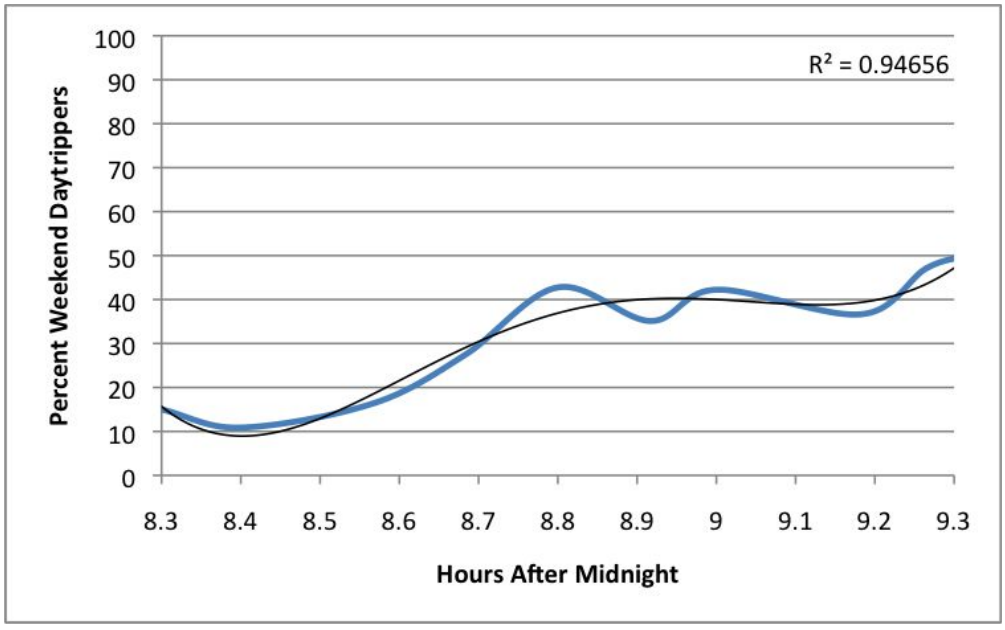


Figure 4.6 Percent of weekend train riders that are daytrippers by time of day

For reference, the polynomial describing this trend line is:

$$y'''(x) = -(79.977)x^5 + (4,144.1)x^4 - (83985)x^3 + (836,530)x^2 - (4 * 10^6)x + (8 * 10^6)$$

During the weekend count, the team also conducted reliability surveys. These reliability tests for predicting whether passengers were commuters or tourists showed a 91% accuracy rate. The team also took the opportunity to find out whether tourists were first time visitors, or had been to the city before, because there was little available information about how many of Venice's visitors are repeat tourists. The team found that twenty of the thirty tourists surveyed were first time visitors.

Overall, the counts the team conducted present interesting information about commuters and and daytrippers entering the city. As expected, the number of commuters dwindles as the afternoon approaches because workers have to be at work. On weekends, the percent occupancy of commuters drops drastically, since most people only work during the week and not on weekends. Meanwhile, daytripper arrivals on both weekdays and weekends seem to rise to a maximum in the late morning, then dwindle as the afternoon wears on. Even though these conclusions may be obvious, the percent occupancy of commuters and daytrippers by time is incredibly helpful for understanding when and how people arrive in the city. The equations built from this information were used to build the train widget discussed later in this chapter.

For a full listing of all trains counted, see Appendix I & J. Using scale factors identified in the 2009 COSES report,[58] the team estimated the monthly arrival distributions of daytrippers and commuters over the year. The full distribution data can be found in Appendix I. Figure 4.7 and 4.8 present the weekday commuters per month and weekday daytrippers per month, respectively. Figure 4.9 and 4.10 present the weekend commuters per month and weekend daytrippers per month, respectively.

[58] Scaramuzzi et al, pg 125

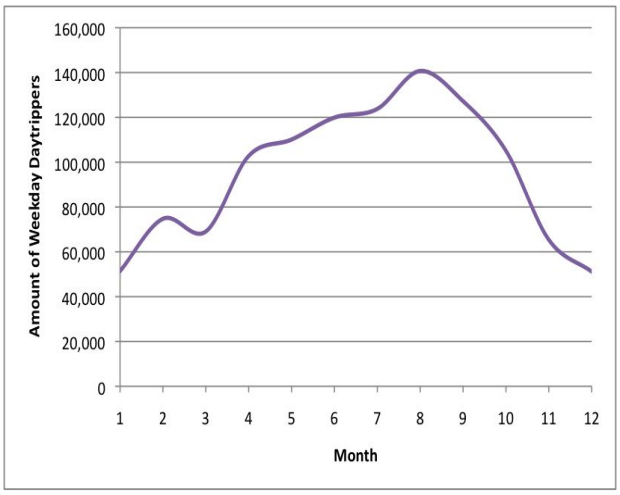


Figure 4.7 Weekday Daytrippers per Month

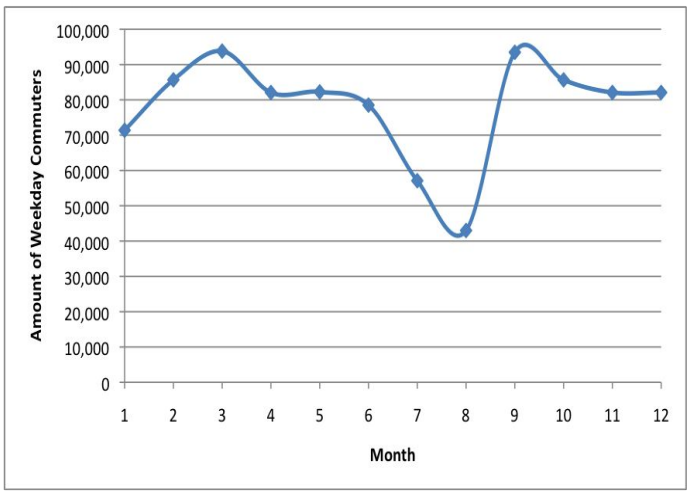


Figure 4.8 Weekday Commuters per Month

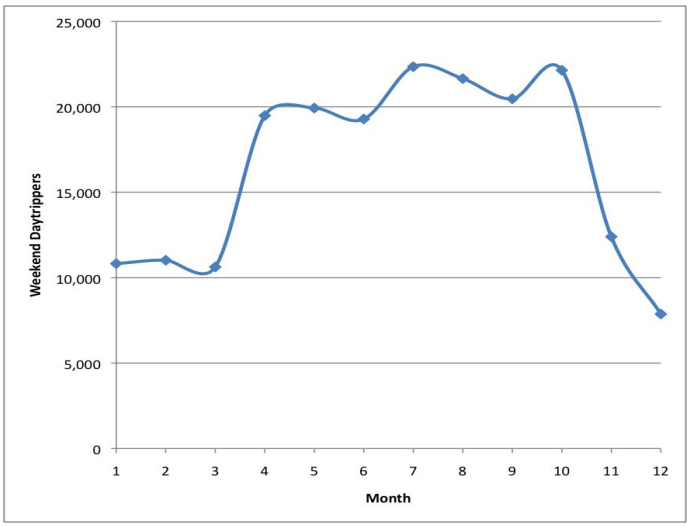


Figure 4.9 Weekend Daytrippers per Month

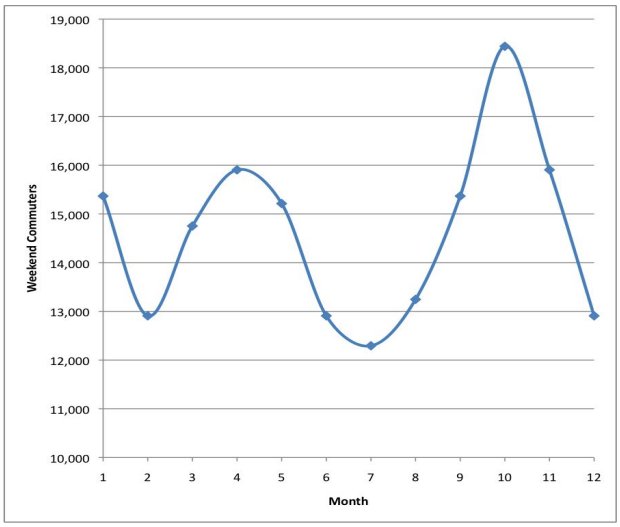


Figure 4.10 Weekend Commuters per Month

In order to help visualize tourism information collected by the VPC, the team created three widgets on the Venice Dashboard. The sources of data for these widgets is described in Chapter 3, section 1.

The Train Widget pictured in Figure 4.11 shows the most recent train arrivals and the total arrival of tourists via train for the day. Each row in the train board represent a different train arrival. The train arrival contains the time of arrival, the starting location of the train, the track it arrived on, and the number of people who arrived on that train. The "Total Arrivals" box contains the sum of people that arrived on each train for that day. Then the top boxes divide this total into just tourists.

Figure 4.11 The Train Widget

Additionally, the team updated widgets that already existed on the Dashboard. These widgets include the tourist arrivals widget and the hotels widget. Much of the data on these widgets were estimates based on ratios provided by the 2009 COSES report. The team improved the sources of these data, to increase the accuracy of the numbers displayed in these widgets. The sources of the train arrivals in the tourist arrival widget were improved by the teams train counts, the train spreadsheet, and data scraping. The hotel widget was updated by improving and updating the internet data scraping process.

The AirBnB Widget pictured in Figure 4.12 shows current occupancy of Airbnb bed and breakfast locations within Venice. Each circular "pie" represents a different district within Venice. The number in the middle of each pie is the current occupancy of that district. The completion of the pie represents the percent occupation of that district. For example, the pie for the Cannaregio district is about ⅞ filled, or 87.5%. The true occupancy of the Cannaregio is 666 people. The sum of these true occupancies make the total booked rooms, which is displayed in the "TOTAL" pie and the "Booked Rooms" box. The "Total Rooms" box contains the total *available* rooms. Then the "Avg. Availability" is the percent average of availability of the districts. "Avg. Price" is the nightly average cost of each bread and breakfast.

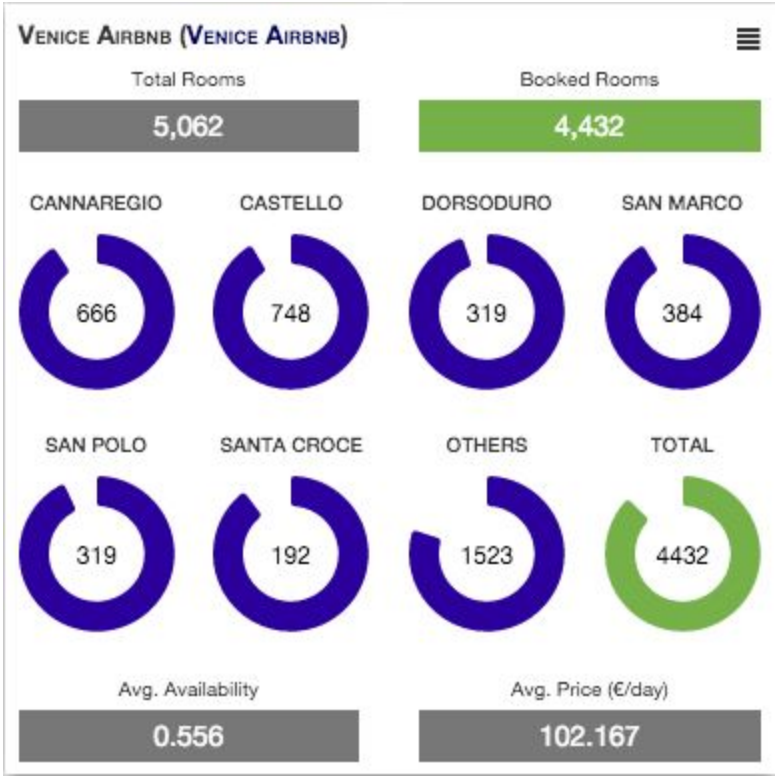


Figure 4.12 The AirBnB Widget

The last widget created was a Presence Widget (shown in Figure 4.13) which displays the daily occupancy of the city of Venice. It has two curves, one for the number of residents and one for the number of tourists in the city. As afternoon approaches, the number of tourists increases whereas the number of residents remains relatively constant. The helpful aspect of this widget is that it visualizes the problem that Venice is currently facing: residents are being outnumbered by tourists. Ideally there should be fewer tourists in the city than residents, but the widget shows that there are often more tourists in the city than residents.

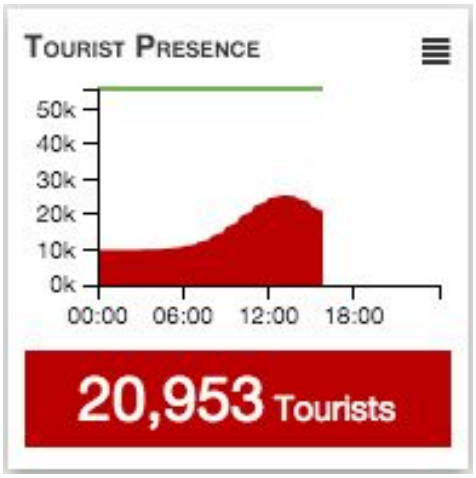


Figure 4.13 The Presence Widget

Overall, these widgets are helpful because, previously, the Venice Dashboard lacked information about AirBnB occupancies and train arrivals. Understanding the daily occupancy of Venice is incredibly important for tourism management. The group believes that the updates made to the Venice Dashboard will continue to help the city handle tourism.

4.2 Establishing the Maximum Sustainable Occupancy of Venice

The first step to finding the maximum sustainable occupancy of Venice was to measure all forms of egress out of the green area, as introduced in Chapter 3. The required measurement was the smallest width of each of the green area's seventeen bridges. This particular width yields a bottleneck for the flow on each bridge. Table 4.2 displays this limiting walking width (in meters) for each bridge. Equation **(6)** was introduced in Chapter 3, as well the value of the parameter for "Flow Rate", 66 People/meter*minute, and "Time", 8 minutes. Plugging in the values for flow rate and time yields Equation **(7)**.

$$Individual\ Egress\ Occupancy = (Flow\ Rate) * (Time) * (Bridge\ Width) \quad \textbf{(6)}$$

$$Individual\ Egress\ Occupancy = (66\ people/min/meter) * (8\ minutes) * (Bridge\ Width) \quad \textbf{(7)}$$

Table 4.1 displays the individual egress occupancy for each of the seventeen bridges in the green area.

Table 4.1 Walking widths of egress points

Bridge of Egress	Limiting Width (meters)	Individual Egress Occupancy
Ponte della Paglia	6.58 m	3470
Ponte di Canonica	2.00 m	1060
Ponte del Rèmedio	1.54 m	813
Ponte de l'Anzolo	1.80 m	950
Ponte de la Guerra	2.35 m	1240
Ponte Balbi	1.49 m	786
Ponte de la Malvasia	1.40 m	739
Ponte de la Fava	1.53 m	808
Ponte Sant'Antonio	2.62 m	1380
Ponte de l'Olio	2.70 m	1430
Ponte San Moisè	4.77 m	2520
Ponte de Piscina	2.71 m	1430
Ponte dei Barcaroli	1.72 m	908
Ponte de la Cortesia	2.86 m	1510
Ponte San Paternian	1.39 m	734
Ponte del Teatro	5.40 m	2850
Ponte di Rialto	12.13 m	6400

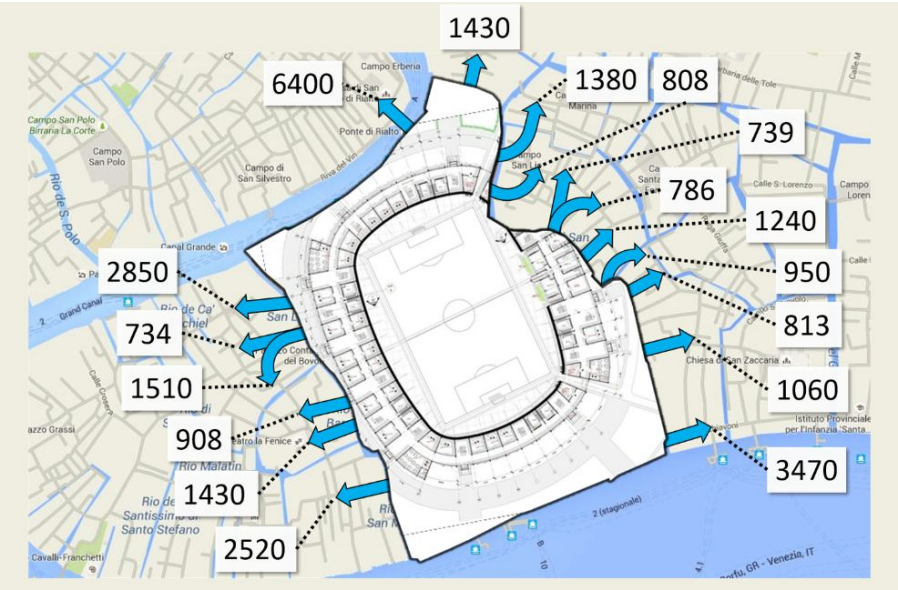


Figure 4.14 The individual egress occupancy for each bridge out of the green area

The team then summed all seventeen egress occupancies for each respective bridge. This formula is presented below in equation **(8)**.

$$Maximum\ Occupancy = \sum_{i=0}^{n} (individual\ egress\ occupancy),\ n = number\ of\ bridges \quad \textbf{(8)}$$

Solving Equation **(8)**, the maximum occupancy of the green area is:

Maximum Occupancy ≈ 29,000 People

The estimated 29,000 people represents that could safely evacuate the green area according to the safety codes introduced in Chapter 3. The next step was to determine the maximum allowable number of daytrippers in this area. For sake of clarity and space, Table 4.2 lists all abbreviated variables used in the upcoming equations.

Table 4.2 List of Abbreviated Variables

OGA	Estimated # of overnighters in green area
RGA	Estimated # of residents in green area
CGA	Estimated # of commuters in green area
BED	Estimated # of beds in green area
TNO	Total # of overnighters in the historic Venice

The maximum occupancy is the sum of residents, commuters, overnighters, and daytrippers. This formulas is presented below.

$$Max\ Occupancy = Residents + Commuters + Overnighters\ +\ Daytrippers \quad \textbf{(9)}$$

The team then applied the abbreviated variables in Table 4.3 to acquire:

$$Max\ Occupancy = RGA + CGA + OGA\ +\ Daytrippers \quad \textbf{(16)}$$

Therefore, the maximum number of daytrippers is found by:

$$Max\ Daytrippers\ =\ (Max\ Occupancy) - (OGA) - (RGA) - (CGA) \quad \textbf{(17)}$$

So the group needed to solve for the variables OGA, RGA, and CGA.

Starting with overnighters, the number of overnighters in the green area can be approximated by adding the number of hotel beds for each island in the green area plus a fraction of the total number of overnighters. The number of beds for each island in this area is presented below in Figure 4.15. The total sum of beds is equivalent to the number of overnighters.

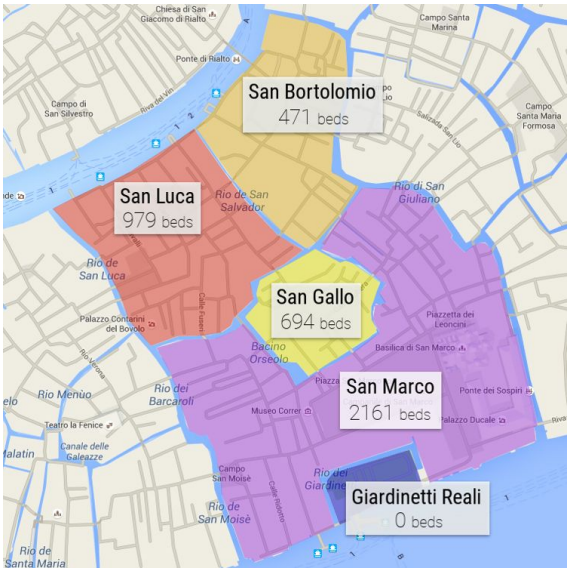


Figure 4.15 The number of beds (overnighters) in each island of the green area

$$BED = 471\ +\ 979\ +\ 694\ +\ 2161\ +\ 0\ =\ 4,305$$

This result did not account for potential overnighters from elsewhere in the historic city, who could be in the green area. The Annuario calculated that the average overnight stay in

Venice for 2014 to be 2.33 days. The team then made the assumption that overnighters outside the green area would be in that area for at least one day out of their estimated average stay.

To calculate the potential overnighters in the green area, the team had to account for both the beds in the area and the overnighters outside the area, as to avoid double counting. This was achieved by taking the difference of the total number of overnighters in the historic city and subtracting the number of beds in the green area. The difference was then divided by the estimated average stay and then added to the number of beds in the green area to acquire the desired overnighters in the area.

$$OGA = \frac{(TNO - BED)}{2.33} + BED \quad \textbf{(18)}$$

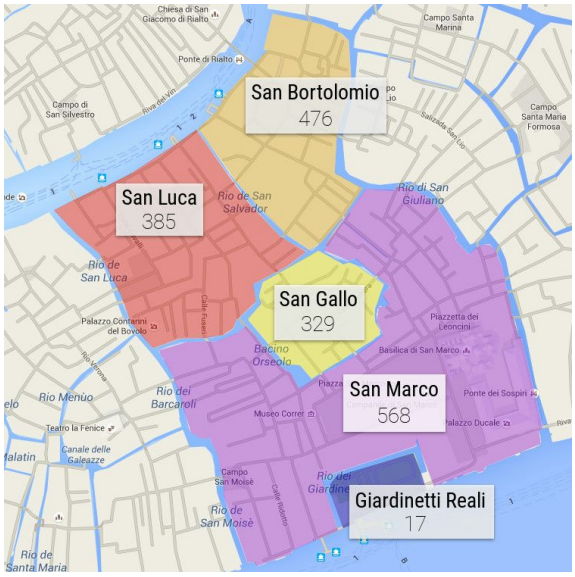
The fraction of total overnighters in the green area was then calculated:

$$\frac{TNO - BED}{2.33} = \frac{17{,}600 - 4{,}305}{2.33} = 5{,}706$$

Therefore,

$$OGA = 5{,}706 + 4{,}305 \approx 10{,}010$$

For resident population, the team used the 2011 census tract, which can be seen in Appendix G. The team then summed up the population of each island in the green area, as seen in Figure 4.16.



4.16 Resident population from 2011 Census

The sum of these five islands is,

$$RGA = 568 + 329 + 17 + 385 + 476 = 1,775$$

The last component is the number of commuters in the green area, CGA. Using the census, the team determined the number of commuters per island in the green area shown in Figure 4.17.

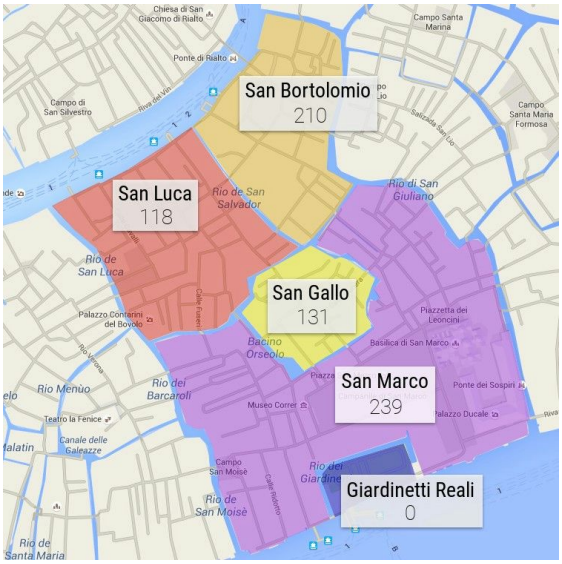


Figure 4.17 2011 Census data for Commuters

The sum of these numbers is,

$$CGA = 210 + 118 + 131 + 239 \approx 700$$

Substituting the values for variables OGA, RGA and CGA, into equation **(17)** yielded the maximum number of daytrippers.

$$Max\ Daytrippers = (Max\ Occupancy) - (OGA) - (RGA) - (CGA) \quad \textbf{(17)}$$

$$Max\ Daytrippers = 29,000 - 10,010 - 1,775 - 700 = 16,515 \approx 16,520\ daytrippers$$

Therefore the maximum number of daytrippers was determined to be 16,515 per day or 6,028,000 in a year. This prescribed number of daytrippers is lower than the current number of daytrippers by 64 %. This calculation can be found in equation **(18)**,

$$Percent\ Reduction = \frac{Initial - Final}{Initial} \quad \textbf{(18)}$$

$$64\ \% = \frac{16{,}635{,}000 - 6{,}028{,}000}{16{,}635{,}000}$$

Knowing the necessary percent reduction for daytrippers, the team then calculated the total allowable number of tourists, the Tourist Cap, in Venice per year. The value for 2014 is shown below**.**

$$Tourist\ Cap = (Max\ Daytrippers) + (2014\ Overnighters) \quad \textbf{(19)}$$

$$Tourist\ Cap = (6{,}028{,}000\ \tfrac{daytrippers}{year}) + (6{,}425{,}000\tfrac{overnighters}{year}) = 12{,}453{,}000\ tourists$$

From this yearly value, the team calculated an average number of allowable tourists in Venice per day by dividing by 365 days per year.

$$12{,}453{,}000\tfrac{year}{365\ days} = 34{,}120\ \tfrac{tourists}{day}$$

Tourist Cap ≈ 34,000 tourists/day

The team's calculated Tourist Cap for 2014 is very close to the estimated tourist cap of 33,000 per day proposed by COSES[59]. However, this number should be taken as a conservative estimate. Not all of the bridges would be used equally in the event of an evacuation. Tourists, especially, would use popular bridges like Rialto, which would slow down the rate of egress. For a better calculation, real pedestrian counts must be completed at each bridge in consideration. For a proof of concept, the team completed such an analysis for the island of San Bortolomio, which can be found in Appendix K, where the popularity of each bridge was calculated using real data. For example, the analysis proved that Rialto bridge is used five times more than Riva del Carbon at noon. Even without accounting for the popularity of individual bridges, the calculation above represents a conservative estimate. In sum, tourism needs to be reduced significantly.

[59] Scaramuzzi et al, pg 2

4.3 Evaluating Existing Tourism Management Proposals

In order to effectively reduce the number of tourists to a safe level, the city would have to adopt a tourism management plan. The team read five proposals, and then met with their individual proponents. In-depth minutes of each meeting are provided in Appendices A through E. The following is a description and analysis of each of these proposals.

Pass4Venice is an idea that uses a dynamic-cost pass for access to the city. Tourists would have to buy a pass online in the form of a ticket and, once having arrived at the city, pass through one of seven hubs on the outskirts of Venice. The price of the pass would increase as the number of tourists in the city increases, however there is no set maximum. Instead, Pass4Venice uses a soft cap that works by discentivizing. When the tourist population of the city is under 37,000 the pass would cost € 25. The price of the pass when the tourist population exceeds 100,000 would be € 100. The hope is that tourists would be less likely to visit on busy days and more likely to visit during less popular times of the year. The end goal is that tourist populations would be more spread out throughout the year. Pass4Venice also encourages early registration, as the pass would be cheaper for those who plan ahead. In the end, it is estimated that Pass4Venice may generate up to 700 million Euros a year from pass revenue. The proponents also claim the dynamic-cost price may diminish the number of tourists entering the city by 30%.

S.Marco Pass is another initiative focused on controlling tourism, but on a smaller scale. By reducing the scale of focus, creator, Marco Scurati, hopes to avoid the legal ramifications of a city wide proposal like Pass4Venice. The initiative is focused on controlling tourist populations in San Marco Square. Unlike Pass4Venice, San Marco Pass prescribes a maximum tourist population of 65,000 per day. To enforce this maximum population, Scurati made the assumption that all tourists want to visit San Marco Square. Therefore, only allowing 65,000 people into San Marco should limit the population of the entire city. S. Marco Pass requires gates to be built at the entrances to San Marco Square and a € 5 entry fee. The pass could be purchased in the city at designated locations or online. The proposal also only requires a purchase of a pass for daytrippers. Access to San Marco Square would always be allowed for overnighters. In this way, S. Marco pass aims to reduces the number of daytrippers and increase the number of overnighters.

Venezia Libera is another developing proposal. The proposer, Roberta Bartoloni, stated that it is "difficult to live here because of so many people" and that "something needs to be done." The concept requires making a free reservation for entry into the historic city, but only a certain number reservations would be available. The exact number of reservations has yet to be determined. Bartoloni believes that charging people for access to the city is illegal and therefore not possible. The registration would be made online with the requirement of a cell phone number to limit the number of reservations reserved by one person. The reservation would be free and directed only at daytrippers. Reservations would be included with overnight stays at hotels registered with the city. In this way, Venezia Libera aims to reduce the number of illegal bed and breakfasts since registration would not be included with a stay at one these. Failure to reserve will result in a fine if caught. To enforce the number of registrations, random checks at San Marco Square would be conducted. Similarly, Venezia Libera would prevent the presence of illegal street vendors since frequent registration would not be allowed. Overall, the goal of Venezia Libera is to reduce daytripper tourist populations as quick as possible.

The next proposal is Ven-us, created by Italia Nostra. The speaker for this proposal, Paolo Lanapoppi, stated that "culture is a magnet to attract business." With that said, the main goal for Ven-us is to reduce the influx of tourist groups by limiting tourism bus companies. Tourist groups are known to clog streets and create traffic delays in Venice. By reducing the number of tourist groups, Ven-us aims to ease the tourist pressure in Venice. Bus companies would be required to adhere to a limited number of buses per year. The hope is that reducing the number of buses also reduces the number of tourist groups. As a result, Ven-us does not set a cap on the maximum population for Venice. In addition, bus companies would be taxed to help raise money for the city. Furthermore, the proposal wishes to reduce the number of apartments being leased to tourists instead of residents. Ven-us would provide tax incentives to landlords who rent to locals as opposed to tourists.

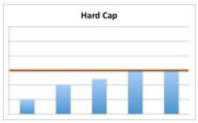
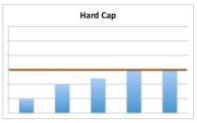
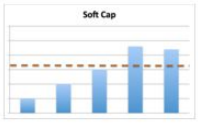
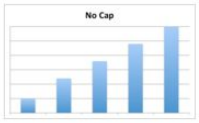
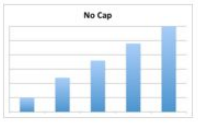
The final proposal is ZTL Revolution, which was presented to the team by Cristiano Farina and Marco Bonaventure. The proposal is not designed to reduce tourism, rather, reduce the negative impacts of tourism. The proposal introduces a € 3 city tax on tourists' use of public transportation and parking in Tronchetto. It also introduces a ZTL charge on incoming boats that dock on the southern coast of Venice near San Marco Square. The goal is to extend taxes to

daytrippers since overnighters already pay a city hotel tax. As a result, overnighters with proof of a hotel reservation will not have to pay the tax when purchasing boat, train or parking tickets. The proof of reservation could be in the form of a number or QR scan code. Also, the cost of the tax might increase during peak tourism seasons and diminish during the low tourism seasons. ZTL Revolution also benefits local shops by allowing them to compete with touristic shops. Overnight guests would receive craft vouchers equal to the price of hotel taxes they paid, encouraging true Venetian craft purchases. Discounts would also be extended to overnighters for public transportation tickets, private and public museum tickets, concert and event tickets, and public toilet tickets. Overall, ZTL Revolution aims to encourage overnighters while generating income for the city.

The different goals, methods, and aspects or each of these proposals are summarized as a matrix in Figures 4.18-19.

Proposal	S. Marco Pass	Venezia Libera	Pass4Venice	Ven-us (Italia Nostra)	ZTL Revolution
Contact	Marco Scurati	Roberta Bartoloni	Andrea Casadei	Paolo Lanapoppi	Cristiano Farina and Marco Bonaventura

Description

Tourist Cap					
Targeted Tourists	Daytrippers	Daytrippers	Daytrippers	Groups of Daytrippers	Daytrippers and Overnighters
Max Tourists Per Day	65,000 per day	Not yet determined. Based on safety.	33,000 per day	Quota on coaches. No cap on population.	No cap

Methods

Area Covered					
Key Assumptions	• All tourists want to go to Piazza San Marco. • If access to Piazza San Marco is limited, fewer tourists will come to Venice.	• Tourists will be willing to register online before coming to Venice.	• Higher entrance costs will discourage tourists from visiting.	• Groups of daytrippers are the most problematic tourists and can be reduced by regulating tour companies.	• Tourists coming into the city can be subjected to new taxes and ZTL laws.
Requirements	• Paid pass to enter S. Marco Square.	• Free reservation to enter the city.	• Dynamically priced pass to enter the city.	• Tourism companies can only bring a limited number of groups to the city.	• Daytrippers to pay ZTL tax.
Services	Give overnighters unlimited access to San Marco Square.	Automatic registration for overnighters.	Give reduced prices to overnighters.	Give tax incentive to land lords who rent to permanent residents.	Give overnighters vouchers to spend on craft goods.
Fee	€5	Free	~ €52	Free	€3
Documentation	Ticket, Card	Phone, Printout	Physical Pass, Wristband	Reservation	City Tax

Figure 4.18 The Matrix

Enforcement and Validation

Validation	Gates at S. Marco Square	Checks at museum, church entrances, ACTV ticket offices.	Checkpoints at City Entrances	Transportation Company	ZTL Officers
Physical Gates	✓	✗	✓	✗	✓
Costs to the City	€€	€	€€€ (€600 mil/yr)	€	€
Implementation Time	🕐🕐	🕐	🕐🕐🕐 (~ 3-4 years)	🕐	🕐

Benefits

Presumed Benefits	• 60% reduction in number of tourists.	• Reduce tourism with minimal legal issues.	• 30% reduction in number of tourists.	• Reduce the number of large tour groups. • Provide funds for cultural preservation.	• Better control of access to the city using ZTL. • Shift the burden of paying city tax from overnighters to daytrippers. • Incentivize spending on local artisans.
Income for City	Not Estimated	None	€700 mil/yr	None	€45 mil/yr

Figure 4.19 The Matrix (Part 2)

After comparing the features of the proposals in a matrix, the team weighed the strengths and weaknesses of each. This assessment was not meant to weigh the relative merits of the proposals as a whole, but rather to identify the best components of each so that those components could be incorporated into the hybrid proposal described in section 4.4. A matrix summarizing the team's assessment can be seen in Figure 4.20. In this matrix, green tiles generally represent aspects the team found to be more favorable, while red tiles represent weak aspects. Yellow represents an aspect that is somewhere in the middle.

Proposal	S. Marco Pass	Venezia Libera	Pass4Venice	Ven-us (Italia Nostra)	ZTL Revolution
Description					
Economic Feasibility	Requires gates to be put up at San Marco, which maybe be expensive to install and maintain.	Requires a relatively small amount of money to develop the online registration portal and to enforce/validate pass owners.	Extremely expensive to develop, maintain, and staff entrance hubs.	Fairly inexpensive to regulate tour companies.	Will require only a small amount of money to enforce new ZTL legislation.
Logistical and Infrastructural Feasibility	Properly constructing gateways into San Marco Square will require several months.	No new infrastructure is needed.	The scale of new infrastructure will take several years to build.	No new infrastructure is needed, but there are potential logistical problems in regulating tour companies.	Minor new infrastructure needed, will take effort to enforce new ZTL regulations.
Legality and Equity Concerns	Limits acces to a public space, which potentially violates Article 3 of the Italian Constitution.	Registration is done on a first-come first-serve basis, so there are few concerns.	The high cost of the pass means that Pass4Venice potentially favors the wealthy. Limiting access to a city also raises conerns about violating Article 3 of the Italian Constitution.	Potentially discriminates against tour companies in that it reduces the amount of business they can do.	Because this proposal only expands existing laws, there are no concerns.
Required Marketing	Medium amount. A daytripper tourist will need to know that they need to get a pass to enter San Marco Square.	Large amount. Will require a marketing campaign to let people know about the registration process.	Large amount. Tourists will need to know far in advance that they must pay in advance to get into Venice.	None.	Medium amount. Transportation service companies will need to know about the new ZTL laws.
Daytripper Limitation	Yes. Limited number of passes to San Marco for daytrippers.	Yes. Hard limit on the number of tourists who can enter Venice in a day.	Yes. Daytrippers need to pay full price for the pass while overnighters are given reduced rates.	Yes. Limits large groups of daytrippers brought in by tour companies.	None.

Figure 4.20 Matrix Summarizing the Team's Assessment

Economic, Logistical, and Infrastructural Feasibility:

The economic feasibility of these proposals has to do primarily with how much new infrastructure would need to be built in order to implement the proposal; so the economic and infrastructural feasibility of the proposals are bound together. Any new infrastructure would have upfront, maintenance, and staffing costs associated with it. Some of the proposals generate income to offset new infrastructure and logistical costs, while others do not. Additionally, new infrastructure takes time to build and implement correctly. With tourism being such a pressing issue in Venice, solutions that avoid large amounts of new infrastructure and allow to be implemented quickly are generally more feasible than those that will take more time and money to implement.

The least feasible proposal in terms of economics, logistics, and infrastructure required is Pass4Venice. This proposal would require the city to build seven new entrance hubs by which people would enter Venice. These hubs are large, take a long time to build (Pass4Venice estimates three to four years), require traffic and transportation routes to be rebuilt around them, and are very expensive. Pass4Venice includes provisions to amortize these upfront costs over 10 years and pay for them with the income made by selling entrance passes; however, large construction projects like this can often run far over budget in terms of both money and time. This means that the upfront costs of the project are eminently important, regardless of any plan to pay off the costs over time. Therefore, while building these hubs might be a good solution in the long term, their huge upfront costs in terms of time and capital mean that this proposal is not a feasible solution for the city's immediate tourism problem.

In terms of economics and infrastructure, S. Marco Pass is more feasible than Pass4Venice. For this proposal, rather than a network of entrance hubs, the new infrastructure would take the form of gates or turnstiles at Piazza San Marco. Since San Marco is the most popular tourist destination in the city and is very historically important, implementing gates there would be a matter of some delicacy. It is also a large area with a number of possible entry points, so the number of gates would have to be fairly large in order to accommodate the large number of people who move through the area. Therefore, while implementing S. Marco pass would not require as much infrastructure work or money as putting gates at every entrance to the city, the amount of new infrastructure and money involved would not be insignificant.

Economically and infrastructurally speaking, the most feasible proposals are Venezia Libera, Ven-us, and ZTL Revolution. For all of these proposals, no major infrastructure projects would be necessary. For Venezia Libera, the main costs would be developing and creating a web portal for tourist registration. Ven-us would only incur costs in regulating tour companies and providing incentives for landlords to rent to permanent residents. Finally, ZTL Revolution's only real cost would be regulating the new ZTL areas the proposal establishes.

Legality and Equity Concerns:

An additional important point to consider when analyzing the different tourism management proposals is whether or not the proposals would be allowable by Italian law. There are two articles in the Constitution of the Italian Republic that concern the free movement of Italian citizens within the country. The first is Article 3, which states that, "It is the duty of the Republic to remove those obstacles of an economic or social nature which constrain the freedom and equality of citizens."[60] The second is Article 16, which says, "Every citizen has the right to reside and travel freely in any part of the country, except for such general limitations as may be established by law for reasons of health or security."[61] These articles suggest that protecting the free movement of Italian citizens is a paramount duty of the government. This means that any tourism management plan that impedes the access to Venice may be in question.

The key phrase that needs to be discussed is, "travel freely."[62] The legality of limiting access to Venice is going to largely depend on how the government interprets this phrase. One possible interpretation is that Venice is not constitutionally allowed to charge money for access to the city. In this case, Pass4Venice would be seen as illegal, as it would require people to pay money in order to get a pass to enter the city. Similarly, since S. Marco Pass would require people to pay to get into Piazza San Marco, a public space, it may also run afoul by this interpretation of Italian law.

A second interpretation of the law might be that Venice is not allowed to set a cap on the number of people able to enter the city, as that would also impede the ability of people to travel freely. In this case, Venezia Libera might be considered illegal, as it establishes a hard cap on the

[60] *Constitution of the Italian Republic*, art. 3
[61] *Constitution of the Italian Republic*, art. 16
[62] Ibid

number of people able to enter the city. S. Marco Pass might also be considered illegal under this interpretation, as it sets a hard limit on the number of people able to enter Piazza San Marco.

At first glance, this may seem like bad news for the possibility of implementing a robust tourism management plan in Venice. Fortunately though, Article 16 of the Italian Constitution offers a solution to the free travel problem, as it says, "except for such general limitations as may be established by law for reasons of health or security."[63] Therefore, if the Italian government sees overcrowding in Venice as a legitimate threat to the safety and security of the residents of Venice, then limiting the number of tourists entering the city would be entirely legal. In this way, the maximum occupancy calculations within this project are eminently important, as they indicate that the number of people that currently occupy Venice every day is very unsafe if an evacuation were to occur, thereby legitimizing a cap on the occupancy of the city.

Required Awareness Campaign:

An important aspect in the implementation of any of these proposals would be letting tourists know that Venice is changing how tourists are managed. The only one of these proposals that would not require some sort of major campaign push would be Ven-us. This is because individual tourists are not affected by this proposal, so would not need to know about its implementation.

The proposals that would require the largest campaigning are Venezia Libera and Pass4Venice. Since Venezia Libera involves tourists registering before coming to the city, the city would need to let potential tourists know about the registration process and encourage them to complete it. Similarly, tourists would need to know about buying a pass through Pass4Venice before visiting the city. For both of these proposals, an effective global information campaign would be of great importance, since the city would want to avoid turning people away after already arriving in Venice. Doing so would make tourists very angry and potentially earn the city very poor media coverage.

For S. Marco Pass and ZTL Revolution, a global information campaign is not as important as Venezia Libera and Pass4Venice, but some sort of information dissemination would probably still be necessary. For S. Marco Pass, this is due to the fact that tourists need to know that they must buy a pass to enter San Marco and that there are only a limited number of passes available per day. ZTL Revolution would also need a small advertising campaign to ensure that transportation companies and operators are aware of the new ZTL areas and how the new laws would affect them.

[63] Ibid

Daytripper Limitation:

Compared to overnighters, daytrippers are the less desirable tourists. This is because daytrippers contribute significantly less to the city's economy and tend to travel around the city in large groups, often clogging up streets and slowing down traffic. Therefore, whether or not a proposal takes steps to limit the number of daytrippers that enter the city is important.

Of the five proposals, the only one that does not do something to limit daytrippers is ZTL Revolution. In fact, ZTL Revolution does not limit tourism in any way, but instead focuses on regulating where and how tourists get into the city.

Pass4Venice and Venezia Libera do the most to actively limit the number of daytrippers who come into the city. This is because both of these proposals take steps to limit the number of daytrippers who enter the city. For Pass4Venice, this limit comes in the form of a dynamically-priced pass that could rise in price to levels where a daytripper would be unwilling to pay to enter the city. Meanwhile, Venezia Libera sets a hard limit on the number of registrations that it would give out to daytrippers.

S. Marco Pass and Ven-us also limit daytrippers, but to a lesser degree. Ven-us only limits large groups of daytrippers by regulating the tour companies who bus them into the city. S. Marco Pass would limit the number of daytrippers able to go to San Marco. While this would lessen the number of daytrippers coming into the city due to San Marco being the main tourist attraction in the city, the proposal would not actively prevent daytrippers from coming into the city.

Using our descriptive matrix and analysis, the team determined the key criteria that should be present in an effective tourism management proposal. The team also identified the specific strategies used in the five proposals examined above that would help to meet these key criteria. The team considered the following criteria below in Table 4.3 to select the specifics of the hybrid tourism management proposal described in section 4.4.

Table 4.3 Important Management Criteria

Criteria	**Why the Criteria is Important**	**Strategies from Proposals**
Immediate Action	The city is at a crisis point and needs to put measures in place to deal with tourism as soon as possible. An effective proposal would have aspects that could be implemented quickly.	● Venezia Libera suggests a registration system that requires no new infrastructure. ● Ven-us suggests only regulating tour companies. ● ZTL Revolution suggests only expanding existing ZTL laws.
Gradual Restrictions	The best way to begin managing tourism is to do so gradually. This will allow the city to implement measures over time and evaluate whether they are working,only stiffening restrictions as necessary. It will also allow the city time to deal with any legal obstructions, should they arise.	● Ven-us suggests beginning by focusing only on tour groups to begin with, rather than trying to manage all tourists. ● Soft caps and voluntary registrations may be a better way to begin restrictions, only increasing to hard caps and mandatory registrations over time
Reduction to Max Occupancy	In order to keep the city safe, a good tourism management solution should specify a maximum safe occupancy for the city.	● Although occupancies are sometimes specified, none have been developed from safety standards. This value comes from Objective 2 of this report.
Income Generation	An effective tourism management plan will incur infrastructure and management costs. A good proposal should have provisions to cover some of these costs.	● ZTL Revolution suggests using its new ZTL areas to force daytrippers to pay the same small city tax that overnighters already do. ● Pass4Venice charges a price for entrance tickets that would cover the costs of building entrance hubs.
Focus on Daytrippers	Daytrippers contribute less to the city's economy and more to the problem of overcrowding than do overnighters. An effective solution will focus on limiting the number of daytrippers.	● S. Marco Pass makes daytrippers pay to get into San Marco, but offers overnighters free, unrestricted access. ● Venezia Libera only requires daytrippers register to enter the city. ● Pass4Venice charges full price to daytrippers, but offers overnighters discounts. ● Ven-us focuses exclusively on limiting large groups of daytrippers.

4.4 Proposing a Hybrid Tourism Management Proposal

By taking inspiration and ideas from the various tourism management proposals examined in Objective 3, the team built a hybrid tourism management plan. This plan should not be taken as a full guide for the implementation of a tourism management solution. Rather, it is meant to serve as a framework of ideas for how tourism can be sustainably managed. These ideas are laid out in stages. Measures that can be implemented in the near future are laid out in the short-term stage. Meanwhile, ideas that are more involved or would take longer to implement are described in the medium and long term stages. In this way, when actually implemented, the effects of each stage can be evaluated before spending more time and money developing the further stages of the solution.

Short Term (less than one year):

The first stage of this plan would be an expansion on the ideas set forth in Venezia Libera, where tourists would be encouraged to complete a free registration before coming to the city. This reservation would allow a tourist access to certain useful services in the city. These would be services already managed, at least in part, by the city, and include the ACTV, Alilaguna, civic museums, and public restrooms. Those without reservations could still enter the city, but would be restricted from using these services. There would be a limited number of reservations equal to that of the maximum occupancy calculated in Chapter 4.2-- 34,120 reservations. Overnight guests would be granted a free reservations in combination with their hotel reservation. In this way, the team's proposal aims to reduce the number of daytrippers.

To prove that they have properly made a reservation, tourists would simply need to keep a printed email confirmation number or display it on their phones when using the above services. The team feels that these services are important enough that the idea of losing their use would effectively disincentivize tourists from coming without having made a reservation beforehand. Additionally, it might encourage potential daytrippers to stay overnight, since they would be guaranteed a registration with a hotel reservation in the city. In the interest of fairness towards the city's permanent residents, some portion of the overall number of reservations would be given to residents to distribute to their friends and family as they see fit.

In order to properly implement this reservation system, the city would have to build a robust, easy to use, web portal. The web portal would be most usefully implemented as an extension of the city's already existing website. The following is a suggestion for how this web portal might work and the features it should offer.

The first page of the web portal would have a calendar listing all of the days where reservations are available. A tourist would then be able to register himself or herself (and their entire group, if they desire) for a specific day. If that tourist attempted to register for multiple days in a row, the website would advise them that this reservation is included with hotel stays in the city. After selecting a reservation day and filling in information to complete the registration, a tourist would be presented with the option to buy different city service packages such as a Venezia Unica or museum pass. This would help to raise awareness for these service packages and increase the number of tourists who use them.

In addition to the reservation system, a number of other steps can be taken in the short term to manage tourism. Firstly, as the ZTL Revolution proposal suggests, the city's ZTL laws could be expanded to control more forms of access to the city. Currently, buses are already subject to a ZTL, but the city could expand this idea to affect boats as well. In this way, the city could more easily regulate the number of boats carrying tourists into the city. The revenue from these new ZTL regulations could be used to help offset some of the costs of implementing the tourism management plan.

A second step that could also be taken is the regulation of tour companies. It is common practice for these companies to bus in large groups of daytrippers from areas around Venice. These groups contribute significantly to how clogged the city's streets can become on high tourism days. As the Ven-us proposal suggested, it would be prudent to limit the number of people that these companies are allowed to bring into the city.

An important additional aspect of this first tourism management phase will be informing potential tourists. This will be extremely important in order to inform the worldwide tourist population that Venice is adopting tourism management policies that will affect how many people can visit. Building public awareness would take time but there are many strategies for doing so. For example, tourists flying into Marco Polo airport could receive a disclaimer from their airline about the new tourism management plan and how they might be affected by it. Similarly, tourist web pages like Tripadvisor® could be used to let potential tourists know that Venice is changing its tourism policy. This public awareness campaign will be very important because the registration process's ability to effectively disincentivize people from visiting once the reservation limit is reached is heavily dependent on potential tourists being aware of the registration system. Figure 4.21 below visually shows the four steps required for stage one.

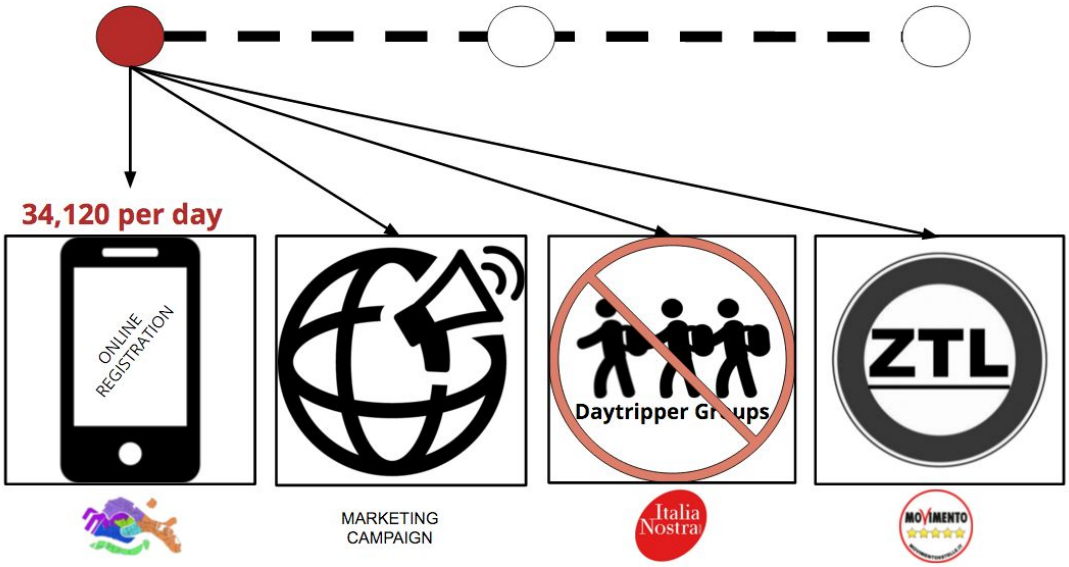


Figure 4.21 The Main Components of Stage One

Medium Term (less than 5 years):

The second stage of this tourism management solution is designed to strengthen and build upon the first stage. At this stage, the registration process to enter the city would no longer be optional, but would be mandatory. Reservation numbers would still be limited to the same 34,120 tourists per day safety. During this phase of implementation, the city could also explore adding a small city tax to these registrations in order to shift the tax burden away from overnighters onto daytrippers.

In order to effectively check that tourists are making reservations, the city would need to check reservation numbers of tourists entering the city. Similar to the ideas proposed in Pass4Venice and San Marco Pass, there would be checking stations at important entrances to the city, such as Tronchetto, Piazzale Roma, and Ferrovia. Figure 4.22 shows these locations in the city.

Figure 4.22 Checking Stations Locations for Stage Two

Entrance to the city from these points requires tourists to cross a bridge, making this an ideal location to check for registration passes. The city would install turnstiles, similar to the ones already used at ACTV stations, to validate registrations. Systems like these are typically capable of reading a barcode off a phone or piece of paper, so at this stage it would be unnecessary for tourists to carry a physical pass (like a Venezia Unica pass or something similar). To ensure ease of access for local Venetians and commuters, one of these bridges, possibly Ponte Secondo S. Chiara off of Piazzale Roma, could be dedicated to only Venetian and commuter traffic. Figure 4.23 below visualizes the two steps for stage two along with the optional city tax.

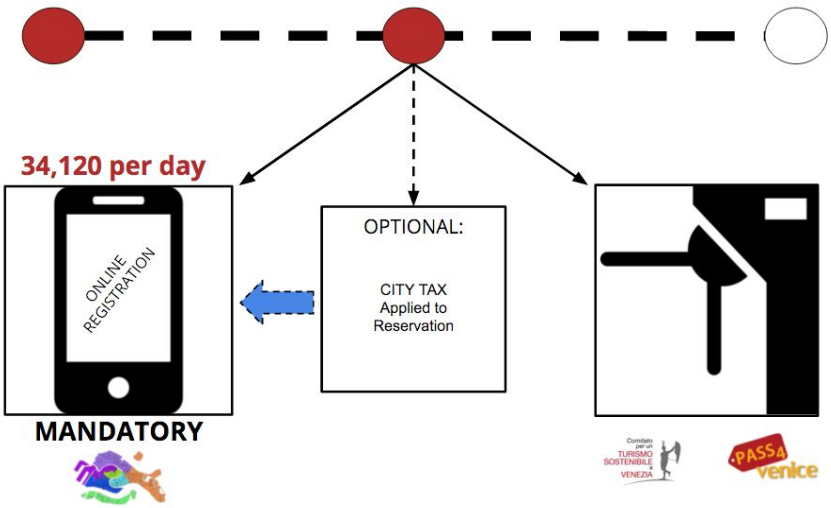


Figure 4.23 The Main Components of Stage 2.

Long Term (more than 5 years):

The third and final stage of the tourism management policy involves the largest amounts of time and money. If the pass checking method in the medium term phase did not work correctly, then it would become absolutely necessary to build large entrance hubs as suggested by Pass4Venice. These hubs are conceptually visualized in Figure 4.24.

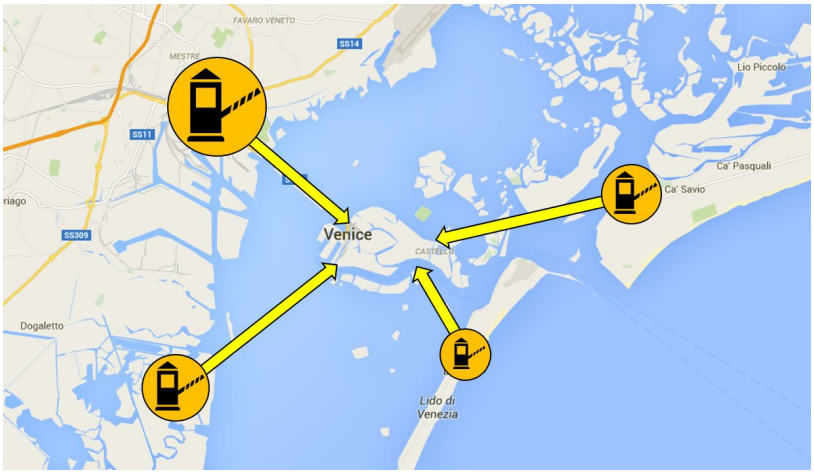


Figure 4.24 Stage Two Hubs

The city would require everyone to enter Venice through one of these hubs. People or companies trying to circumvent the entrance hub system should be fined, or otherwise penalized, by the government. The location and nature of these hubs has not been determined in this project, but, as the Pass4Venice proposal suggests, the hub network could be implemented using seven hubs placed outside the city at mestre via righi, mestre stazione, punta sabbioni, tessera airport, chioggia, fusina, and venezia "lagunare." As an additional measure to help pay for the entrance hubs, a price could be added to the pass. The concepts for stage three are shown below in Figure 4.25.

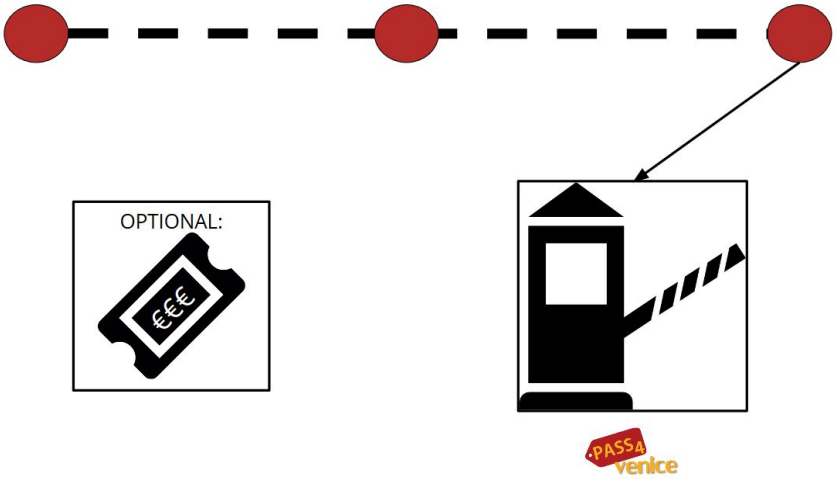


Figure 4.25 The Main Components of Stage Three

5. Conclusions and Recommendations

In this project, we estimated the current occupancy of Venice by drawing on previously collected data on tourists, residents, and commuters, and by collecting new data about train arrivals and tourists staying at bed and breakfasts in the city. The new data aided in the creation of two widgets on the Venice Dashboard, one that counts train arrivals and another that tracks the occupancy of bed and breakfasts each day.

The team also determined a maximum safe occupancy for the city by determining the maximum occupancy for the most visited area of the city. We used this maximum occupancy data to analyze existing proposals on tourism management in order to create a feasible, hybrid plan for tourism management that draws on the best ideas from all current proposals.

5.1 Current Occupancy of the City Versus Maximum Safe Occupancy

In estimating the current occupancy of the city, the team used the most accurate and up-to-date data available on the number of tourists (daytrippers and overnighters), the number of residents, and the number of commuters who are in Venice each day. The team had reliable numbers on residents and commuters from census data and city publications, as well as on overnighters (from city data on hotel, bed and breakfast, and hostel stays), but had to estimate the number of daytrippers in the city. According to our calculations, the total current occupancy of Venice is, on average, 141,600 people per day, or 51 million people per year. In the future, work should be done to collect more data on daytrippers in Venice each day to confirm and update our estimates. We suggest doing extensive surveys of tourists during the peak tourism season (namely, during the months of July, August, and September) to determine what fraction of the tourists in the city are daytrippers.

The team replaced estimated numbers of people arriving in the city by train with numbers based on actual, recent counts we conducted in December 2015. The number of commuters, daytrippers, and overnighters arriving in the city by train will now appear on the VPC's train widget, an online counter that displays train arrivals projected from our 2015 counts. In the future, teams should work to update these counts during the peak tourism season to make the projections more exact. Additionally, in order to get a more complete picture of the total number of commuters entering Venice every day, future teams should replace estimated numbers of car and bus arrivals with numbers based on actual, periodic counts.

By analyzing the most congested area of the city, an area that most tourists will pass through in the course of a day, the team was able to estimate the maximum number of tourists

that can be allowed into the city before it becomes unsafe. This was done by treating the most congested area of Venice, which the team identified as the section of the sestiere of San Marco between the Rialto bridge and Piazza San Marco, as a stadium with a limited number of egress points. Doing so allowed the team to apply international standard safety codes to the area, which were used to calculate the area's safe occupancy. The safe occupancy number is 34,120 tourists per day or 12.45 million tourists per year. This means a 64% reduction in the average number of daytrippers in the city everyday, and an overall reduction of 46% in the number of tourists in the city.

In the future, the occupancy limits determined in this project could be recalculated and made even more precise. In this project, the team assumed an even distribution of people through our area of analysis of who would disperse themselves evenly at all available exit points (bridges) in case of emergency. This is a best case scenario, however. It is likely that pedestrians would crowd onto the most well-known bridges, creating possible bottlenecks that would slow egress.

In the future, a team should calculate the actual pedestrian flow rates for every bridge in the area of analysis. The team did not have enough time to do this for every island, but an example flow rate calculation for the island of San Bortolomio can be found in Appendix K. Additionally, the team's occupancy calculations relied solely on the widths of different bridges, but pedestrians must move through narrow streets to reach these bridges, so a future team should find a way to incorporate the areas of streets, especially the high congestion pathways identified in the 2009 COSES report, in their calculations. Finally, this project uses a number of educated assumptions to estimate the number of people who are in the area of analysis during the day. A future team could make this figure more exact by surveying tourists about their travel habits within the city and by building a full pedestrian movement model.

5.2 Hybrid Tourism Management Proposal

The team outlined a three-stage proposals for a sustainable tourism management solution. This proposal includes many of the best aspects of five tourism management solutions the team analyzed, while also attempting to address some of the weaknesses inherent in these other proposals. Our plan proposes an initial tourist registration system for daytrippers, with built-in incentives, such as provisions for using the city's public transport system, which would be automatically applied to overnight tourists, but not unregistered daytrippers. In the second phase, registration would be required and monitored more closely. The number of available registrations would be capped at 34,120 per day, as this is what the team determined to be the maximum number of tourists that can be safely allowed into the city. The plan also includes a third phase, which, should it become necessary, creates a more stringent checkpoint system

around the city to ensure that the 34,120 tourists per day cap is maintained. The new infrastructure required for these checkpoints could be funded, at least partially, by applying a city tax or fee to tourist registrations.

Our seven-week stay in Venice did not permit us to completely build out this solution in detail. A future team should work to elaborate on costs (in terms of money, time, and human capital) of implementation and should write a more detailed plan in collaboration with the city.

This proposal emerged from the groundwork laid out in five other proposals currently circulating in Venice. The team captured these proposals in a matrix, which allowed us to compare and assess the goals, strategies, enforcement mechanisms, and assumptions made by each. Future teams should look to enrich the tourism management proposal laid out in this project by examining updates to those five proposals and gathering information on other proposals that emerge in the near future.

In conclusion, while tourism brings in revenue, the overwhelming number of tourists entering Venice every year, and the increasing commercialization that is occurring to cater them, presents a legitimate threat to the continued preservation of the city. The team hopes that Venice will be able to more effectively regulate the number of tourists coming into the city and keep its occupancy at a safe and sustainable level with a plan such as the one we propose here. This will help to alleviate the problem of overcrowding and allow the city's permanent residents to lead better daily lives and enjoy the beautiful city they call home. It will also help to preserve the city itself, with all of its valuable architecture and cultural treasures, for generations to come.

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Appendices

Appendix A: Pass4Venice Meeting

Start Time: 6:00 pm
End Time: 7:00 pm

Pass4Venice Meeting 11/5/2015

Meeting Attended By: Zachary, Chris, Tommy, William, Lorraine Higgins, Fabio Carrera,
Andrea Casadei

Meeting chaired by: Prof. Carrera
Minutes to be recorded by: Zachary
Secretary: Chris

- Goal: Control access to the city
    - Doing so can raise a lot of money for the city (1.3 billion Euros in revenue)
- Uses data from UNESCO research
- *1988 COSES* says the maximum number of people in Venice is 33,000
- Estimates that there are currently 27 million tourists in the city every year
- Method: Create seven access hubs around the lagoon where people will enter the city
    - Every person will get a physical Pass4Venice card or wristband
- Price for a pass is determined by the number of visitors, time of year, type of visitor, and length of stay
    - median of ~52 Euros
    - Incentivize overnighters
- This proposal is a deterrent, it doesn't prevent people from coming into the city, just charges them more if there is more demand
- Allows flexible scheduling
- Memberships are seasonal
- "city cards are not feasible since such low numbers actually buy them" (~5% of people buy them)

- Including costs for new hubs and costs to run the program, Pass4Venice estimates that the initiative will make 700 million Euros/year for the city
- Ideally, Pass4Venice wants to reduce daytrippers by 30%
    - Based off of recommendations by two COSES reports
    - No clear idea what price points for passes this 30% reduction would require
- Some concerns about legality considering European and Italian laws about restricting free movement

Appendix B: S. Marco Pass Meeting

Start Time: 4:00 pm
End Time: 5:00 pm

S.Marco Pass Meeting 10/28/2015

Meeting Attended By: Zachary, Chris, Tommy, William, Lorraine Higgins, Fabio Carrera,

Marco Scurati

Meeting chaired by: Prof. Carrera
Minutes to be recorded by: Zachary
Secretary: Chris

- Marco worked in internet sector
- Presented same proposal to the city counselor
    - Became a movement
    - Present (before he was elected) mayor called and said it was interesting
        - If elected he said he will improve the plan
- People in the mainland don't know too much about the problem of tourism in Venice, Italy
- It is not possible to give everyone entry to the city because it is limited
- There is a lack of information about tourism in Venice
    - Annuario has information, but also a lot of useless stuff
    - Most tourists don't pay for public transportation, so they are hard to keep track of
    - Only 2 million go to museums
- Estimates is 27 million total tourists/year
- There two types of tourists: daytrippers and overnighters
    - "Improper" tourists come to the city by happenstance; visiting Venice is not their main goal
    - Mestre tourists are considered daytrippers
    - Cruise ship daytrippers stay for ~ 3 hours
- Public pushback against tourism
    - evident in art like "THE RAPE OF VENICE"

- Multiple people fell in the canal on 7/5/2015 Fondazione Prada x trope caica
- *Minute di terrore in fuel ristorante* (terrorist threat, what could happen for evacuation)
- *"Under siege by tourists"*
- UNESCO might take Venice off of world heritage list because of tourists
    - The future of Venice and its lagoon in the context of global change (UNESCO)
    - Nothing public about what UNESCO is doing yet
- METHODS ALREADY IN USE:
    - Terminals -> tourists are being treated as current flows
    - City tax
    - City pass (Venezia Unica)
- Another initiative: Pass4Venice (dynamic cost)
    - Tourist reservation
    - "Numero Chiuso" means closed number
- 65 percent in the tourist transaction are done electronically
- The image of Venice influences tourists
- Kayak is forbidden
- Tourists board was initially to promote tourists, now they are closed
- Look into Butan, they limit people allowed to enter
    - There is a waiting list
- Marco wants to put limit to main attraction point, Saint Mark's square
    - He determined the number to be 65k
    - This is determined by day not hour
    - Based on research by Van der Borg
- Daytrippers should get this pass, overnighters would not have to
- If the square is full, tourists might:
    - Change period
    - Change year
    - Visit another zone of the city
- ` Not go to Venice at all (estimates this is the case with 60% of people)
- All mass tourists want to go to Saint Marco's square
- Square has only nine access points
    - A lot of study needed for access management
    - Some kind of chip for people like commuters like fast pass

- Schengen agreement says we cannot limit the city
    - Residents want to be able to move around the city instead of allowing free movement of tourists around the city
- Would be cheaper than Pass4Venice
- Soprintendenza might be a problem

Appendix C: Venezia Libera Meeting

Start Time: 3:00 pm
End Time: 4:00 pm

Venezia Libera Meeting 11/4/2015

Meeting Attended By: Zachary, Chris, Tommy, William, Lorraine Higgins, Fabio Carrera,
Roberta Bartoloni

Meeting chaired by: Prof. Carrera
Minutes to be recorded by: Zachary
Secretary: Chris

- Roberta is a concerned citizen
    - She doesn't work in tourism
- "Difficult to live here because of too many people"
- Hasn't been an agreement for a fixed number
- Not legal to have people pay to come into Venice
- Her solution is to have a reservation that is free but obligated
    - Cannot enter venice if you don't have a reservation
    - If you come without reservation you can be fined
- Most tourists are bad except overnighters
- Too many entry points in Venice
    - Doesn't think a checkpoint will be possible
    - Will cause long lines
    - Might not be possible to do in a big place in Saint Marco
- Pass4Venice would take a few years to implement
    - Been in talks for 20 years
- With Venezia Libera, someone would not be able to buy a lot of tickets and resell
    - Uses phone number so you can't find excess tickets
- This will prevent annoying sellers/vendors
- A lot of apartments use tourists to prevent the paying of taxes
    - Increase tax income

- A cap number has not been established yet

    - should be based on safety concerns
- S.Marco Pass and Pass4Venice are both legally questionable
- She is against Venezia Unica
    - There was older pass, but nobody bought it
    - It is only accounting for a small percentage

Appendix D: Ven-us Meeting

Start Time: 11:30 am
End Time: 12:20 pm

Ven-us Meeting 11/6/015

Meeting Attended By: Zachary, Chris, Tommy, William, Lorraine Higgins, Fabio Carrera, Paolo Lanapoppi

Meeting chaired by: Prof. Carrera
Minutes to be recorded by: Zachary
Secretary: Chris

- This proposal is by Italia Nostra
- Gave proposal to vice minister
- Culture is a magnet to attract business
- Fernando Gardene -> Very famous italian photographer
    - Exhibit is in Saint Mark's Square -> Free (27 pictures)
    - Mayor cancelled exhibit initially because he didn't want to influence the media against tourism
    - Government is in favor of the cruise ships for the money
- FIA is an another group that competes with/works with Italia Nostra
    - Owns space in Saint Mark's Square
    - They took cancelled exhibit that mayor cancelled and put it in their space
    - Vice minister was the president of FIA
- Carrying Capacity was made in 1988 by COSES
- Another method occurred by using stress width and speed
- Another area is the bridge docking by the bridge of sighs
    - 107 authorized boats
    - At least another 50 or 60 that the city does not keep track of
    - Authority over waters is controlled by the port authority, but dock is controlled by the city
        - Creates a legal loophole
    - City and the port authority split income from this dock
- Number of tourists in Venice today is too many

- Daytrippers reduce demand for neighborhood stores and real craft goods
- Ven-us thinks that limiting all tourists is too ambitious in the short term
- Instead, focuses on organized groups of daytrippers that come on tour buses
    - Would give the companies a strict limit on the number of people they can bring into the city
- Also includes plan for something akin to an ‘art bonus’
    - Would give tax breaks to landlords who rent apartments to Venetians rather than tourists

Appendix E: ZTL Revolution Meeting

Start Time: 9:30 am
End Time: 11:50 am

ZTL Revolution Meeting 11/11/2015

Meeting Attended By: Zachary, Chris, Tommy, William, Lorraine Higgins, Fabio Carrera,
Cristiano Farina, Marco Bonaventura

Meeting chaired by: Prof. Carrera
Minutes to be recorded by: Zachary
Secretary: Chris

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Marco Bonaventura -> Marco.m5s.2013@gmail.com

- ZTL is something that already exists. Refers to Zone of Limited Traffic
- ZTL Revolution is a no-cost project. It is also not depending on external funding to public municipality resources.
- Allows everyone to come, avoid close number of number
    - Sustainable
    - Tax enough to allow sustainable flows
    - Money used to give discounts and services
        - For local business, give an instrument to allow competition with tourist shops
- Three different offers:
    - 1. "Craftsmanship Vouchers" (Overnight-stay tourists ONLY)
    - 2."Venice Friend Card" (Overnight-stay tourists ONLY)
    - 3."Venezia Unica City Pass" (ALL tourists)
- Implements a ~3 Euro tax:
- Don’t use hubs as they are too expensive
    - They aim for cards or some sort

    - Aim for public parking too
    - Might add gates at the train station
- Discounts for:
    - public transportation tickets
    - private and public museums tickets entrances
    - concerts and events tickets entrances
    - public toilette tickets entrances

- Overnighters would be exempt
- Allow the access also to people who do not have the possibility to stay overnight.
- Can be invited (Voucher) by resident
- Benefits that might be used in town and that might vary according to season and reservation time.
- From 2014 annual report information, craftsmanship vouchers can be issued for a total cost of 6.5 mln Euro/year (city tax current municipality incorre). By applying this project just to tourist ZTL buses, total cost of Craftsmanship Vouchers would be covered with an extra income of 1.5 mln€.
- In exchange for the payment of the City Tax in Hotel, the overnight-stay tourists will receive the same value Vouchers to be spent only on local certificated craftsmanship shops.
- Instead of closing expensive hubs, our idea bets on a softer system based on exemption of the tax by showing hotel reservation confirmations, employer certifications for workers/students, invitation for relatives and friends visiting city centre residents (this can be done possibly using a smartphone app).
- ZTL Revolution fee payment can be changed depending on season. Average price is 3€ but it might be higher in high season and completely free of charge during low season.

Appendix F: Spreadsheet of all daily train arrivals at Santa Lucia

Categori	Numero tr	Orario	ORA	Minuti	Direttrice provenienza	Provenienza	Materiale treno	Capienza materiale	Riempimento lu-ve stimato	Riempimento sab stimato	Riempimento festivo stimato
R	10000	5:25	5	25	Portogruaro	PORTOGRUARO CAORLE (04:13)	6 medie distanze	450	30%	30%	10%
R	2760	5:33	5	33	Adria	PIOVE DI SACCO (04:40)	ATR 120	230	30%	30%	0%
R	20801	5:55	5	55	Padova	PADOVA (05:05)	Vivalto	560	30%	50%	0%
R	11001	6:16	6	16	Treviso	TREVISO CENTRALE (05:36)	Vivalto	560	50%	30%	0%
RV	2757	6:20	6	20	Padova	PADOVA (05:51)	8 medie distanze	614	40%	10%	0%
R	20803	6:25	6	25	Padova	VICENZA (05:08)	TAF	476	40%	0	0%
RV	5701	6:34	6	34	Castelfranco	BASSANO DEL GRAPPA (05:25)	6 medie distanze	450	50%	50%	0%
R	2762	6:41	6	41	Adria	ADRIA (05:10)	ATR 120	230	50%	50%	0%
R	11003	6:46	6	46	Treviso	UDINE (04:31)	Vivalto	560	50%	30%	0%
RV	2703	6:48	6	48	Padova	VERONA PORTA NUOVA (05:21)	Vivalto	560	50%	0	0%
R	10004	6:50	6	50	Portogruaro	PORTOGRUARO CAORLE (05:38)	6 medie distanze	450	50%	50%	0%
RV	2805	6:56	6	56	Treviso	UDINE (05:07)	7 medie distanze	532	60%	0	0%
R	5703	7:04	7	4	Castelfranco	CASTELFRANCO VENETO (06:04)	ETR 343	219	80%	0	0%
R	20770	7:11	7	11	Padova	ROVIGO (05:34)	TAF	476	60%	40%	0%
R	11005	7:16	7	16	Treviso	TREVISO CENTRALE (06:36)	Vivalto	560	80%	50%	0%
RV	2954	7:18	7	18	Padova	ROVIGO (06:10)	8 medie distanze	614	70%	30%	20%
RV	2204	7:20	7	20	Portogruaro	TRIESTE CENTRALE (05:15)	7 medie distanze	532	100%	50%	30%
R	20805	7:25	7	25	Padova	VICENZA (06:08)	TAF	476	80%	0	0%
RV	2853	7:30	7	30	Treviso	CONEGLIANO (06:33)	Vivalto	560	80%	40%	0%
RV	5705	7:34	7	34	Castelfranco	BASSANO DEL GRAPPA (06:25)	6 medie distanze	450	100%	50%	20%
R	2764	7:41	7	41	Adria	ADRIA (06:10)	ATR 120	230	100%	50%	0%
R	11007	7:46	7	46	Treviso	UDINE (05:31)	Vivalto	560	80%	50%	0%
RV	2705	7:48	7	48	Padova	VERONA PORTA NUOVA (06:21)	8 medie distanze	614	70%	50%	40%
R	10008	7:50	7	50	Portogruaro	PORTOGRUARO CAORLE (06:38)	6 medie distanze	450	100%	50%	0%
R	20807	7:55	7	55	Padova	VERONA PORTA NUOVA (05:42)	TAF	476	80%	40%	0%
RV	2441	7:56	7	56	Treviso	UDINE (06:07)	7 medie distanze	532	80%	40%	40%
R	5707	8:04	8	4	Castelfranco	CASTELFRANCO VENETO (07:04)	ETR 343	219	100%	50%	30%
R	20772	8:11	8	11	Padova	FERRARA (05:59)	TAF	476	80%	40%	0%
R	20877	8:11	8	11	Padova	PADOVA (07:23)	TAF	476	0%	0	50%
R	11009	8:16	8	16	Treviso	CONEGLIANO (07:11)	Vivalto	560	100%	80%	0%
RV	2222	8:18	8	18	Padova	BOLOGNA CENTRALE (06:20)	8 medie distanze	614	70%	50%	0%
RV	2206	8:20	8	20	Portogruaro	TRIESTE CENTRALE (06:10)	7 medie distanze	532	80%	80%	50%
R	20809	8:25	8	25	Padova	VICENZA (07:08)	TAF	476	80%	0	0%
RV	2855	8:30	8	30	Treviso	SACILE (07:17)	Vivalto	560	80%	50%	0%
RV	5709	8:34	8	34	Castelfranco	BASSANO DEL GRAPPA (07:25)	6 medie distanze	450	80%	50%	0%
R	2768	8:41	8	41	Adria	ADRIA (07:10)	ATR 120	230	80%	50%	50%
R	11011	8:46	8	46	Treviso	UDINE (06:31)	Vivalto	560	80%	80%	100%
RV	2707	8:48	8	48	Padova	BRESCIA (06:29)	8 medie distanze	614	70%	50%	0%
RV	2709	8:48	8	48	Padova	VERONA PORTA NUOVA (07:21)	8 medie distanze	614	0%	0	60%
R	24811	8:55	8	55	Padova	BRESCIA (05:50)	TAF	476	60%	60%	0%
R	20811	8:55	8	55	Padova	BRESCIA (05:50)	TAF	476	60%	60%	0%
R	20813	8:55	8	55	Padova	VERONA PORTA NUOVA (06:42)	TAF	476	0%	0	60%
R	24813	8:55	8	55	Padova	VERONA PORTA NUOVA (06:42)	TAF	476	0%	0	60%
R	10012	8:56	8	56	Portogruaro	PORTOGRUARO CAORLE (07:44)	6 medie distanze	450	80%	80%	50%
R	20954	9:00	9	0	Treviso	TRIESTE CENTRALE (05:26)	7 medie distanze	532	80%	80%	0%
R	5711	9:04	9	4	Castelfranco	CASTELFRANCO VENETO (08:04)	ETR 343	219	80%	0	0%
R	20774	9:11	9	11	Padova	FERRARA (06:59)	TAF	476	40%	60%	0%
R	11013	9:16	9	16	Treviso	TREVISO CENTRALE (08:36)	Vivalto	560	60%	80%	0%
RV	2224	9:18	9	18	Padova	BOLOGNA CENTRALE (07:20)	8 medie distanze	614	50%	40%	60%
RV	2680	9:20	9	20	Portogruaro	TRIESTE CENTRALE (07:15)	7 medie distanze	532	50%	50%	50%
R	20815	9:25	9	25	Padova	VICENZA (08:08)	TAF	476	40%	0	0%
RV	2857	9:30	9	30	Treviso	CONEGLIANO (08:33)	Vivalto	560	60%	50%	60%
RV	5713	9:34	9	34	Castelfranco	BASSANO DEL GRAPPA (08:25)	6 medie distanze	450	50%	50%	50%
R	2770	9:41	9	41	Adria	ADRIA (08:10)	ATR 120	230	50%	50%	0%
R	20958	9:46	9	46	Treviso	TRIESTE CENTRALE (05:56)	Vivalto	560	40%	80%	0%
RV	2711	9:48	9	48	Padova	VERONA PORTA NUOVA (08:21)	8 medie distanze	614	50%	40%	60%
R	10016	9:50	9	50	Portogruaro	PORTOGRUARO CAORLE (08:38)	6 medie distanze	450	50%	50%	0%
R	20817	9:55	9	55	Padova	VERONA PORTA NUOVA (07:42)	TAF	476	40%	60%	0%
R	24817	9:55	9	55	Padova	VERONA PORTA NUOVA (07:42)	TAF	476	40%	60%	0%
RV	2444	9:56	9	56	Treviso	TRIESTE CENTRALE (06:56)	7 medie distanze	532	60%	50%	80%
R	5715	10:04	10	4	Castelfranco	CASTELFRANCO VENETO (09:04)	ETR 343	219	20%	0	0%
R	20778	10:11	10	11	Padova	FERRARA (07:59)	TAF	476	30%	60%	0%
R	20776	10:11	10	11	Padova	ROVIGO (08:34)	TAF	476	0%	0	80%
RV	2226	10:18	10	18	Padova	BOLOGNA CENTRALE (08:20)	8 medie distanze	614	40%	50%	60%
RV	2208	10:20	10	20	Portogruaro	TRIESTE CENTRALE (08:15)	7 medie distanze	532	40%	50%	80%
RV	5717	10:34	10	34	Castelfranco	BASSANO DEL GRAPPA (09:25)	6 medie distanze	450	20%	50%	0%
R	2772	10:41	10	41	Adria	ADRIA (09:10)	ATR 120	230	20%	40%	80%
R	11017	10:46	10	46	Treviso	UDINE (08:31)	Vivalto	560	0%	60%	100%
RV	2713	10:48	10	48	Padova	VERONA PORTA NUOVA (09:21)	8 medie distanze	614	40%	50%	60%
R	10020	10:50	10	50	Portogruaro	PORTOGRUARO CAORLE (09:38)	6 medie distanze	450	20%	50%	80%
R	20819	10:55	10	55	Padova	VERONA PORTA NUOVA (08:42)	TAF	476	20%	60%	0%
R	24819	10:55	10	55	Padova	VERONA PORTA NUOVA (08:42)	TAF	476	0%	0	80%
R	20968	10:56	10	56	Treviso	TRIESTE CENTRALE (07:26)	Vivalto	560	0%	0	100%
R	5719	11:04	11	4	Castelfranco	CASTELFRANCO VENETO (10:04)	ETR 343	219	10%	30%	80%
R	20780	11:11	11	11	Padova	ROVIGO (09:34)	TAF	476	0%	0	80%
RV	2228	11:18	11	18	Padova	BOLOGNA CENTRALE (09:20)	8 medie distanze	614	40%	50%	60%
RV	2210	11:20	11	20	Portogruaro	TRIESTE CENTRALE (09:15)	7 medie distanze	532	30%	50%	80%
R	20821	11:25	11	25	Padova	VICENZA (10:08)	TAF	476	10%	0	0%
RV	5721	11:34	11	34	Castelfranco	BASSANO DEL GRAPPA (10:25)	6 medie distanze	450	10%	30%	80%
R	2776	11:41	11	41	Adria	ADRIA (10:10)	ATR 120	230	20%	40%	0%
RV	2715	11:48	11	48	Padova	VERONA PORTA NUOVA (10:21)	8 medie distanze	614	40%	0	0%
R	20823	11:55	11	55	Padova	VERONA PORTA NUOVA (09:42)	TAF	476	10%	40%	0%
RV	2448	11:56	11	56	Treviso	TRIESTE CENTRALE (08:56)	7 medie distanze	532	40%	40%	80%
R	5723	12:04	12	4	Castelfranco	CASTELFRANCO VENETO (11:04)	ETR 343	219	20%	0	0%
R	20782	12:11	12	11	Padova	ROVIGO (10:34)	TAF	476	10%	30%	0%
R	11019	12:16	12	16	Treviso	TREVISO CENTRALE (11:36)	Vivalto	560	20%	0	0%
RV	2230	12:18	12	18	Padova	BOLOGNA CENTRALE (10:22)	8 medie distanze	614	30%	40%	60%

R	20825	12:25	12	25	Padova	VICENZA (11:08)	TAF	476	10%	0	0%
RV	2859	12:30	12	30	Treviso	SACILE (11:17)	Vivalto	560	20%	30%	0%
RV	5725	12:34	12	34	Castelfranco	BASSANO DEL GRAPPA (11:25)	6 medie distanze	450	20%	0	50%
R	11021	12:46	12	46	Treviso	CONEGLIANO (11:40)	Vivalto	560	20%	0	0%
R	11023	12:46	12	46	Treviso	UDINE (10:31)	Vivalto	560	0%	50%	80%
R	10022	12:50	12	50	Portogruaro	PORTOGRUARO CAORLE (11:38)	6 medie distanze	450	0%	0	50%
R	20827	12:55	12	55	Padova	VERONA PORTA NUOVA (10:42)	TAF	476	0%	0	50%
RV	2811	12:56	12	56	Treviso	UDINE (11:07)	7 medie distanze	532	20%	0	0%
R	5727	13:04	13	4	Castelfranco	CASTELFRANCO VENETO (12:04)	ETR 343	219	20%	0	0%
R	11025	13:16	13	16	Treviso	TREVISO CENTRALE (12:36)	Vivalto	560	10%	0	0%
RV	2861	13:30	13	30	Treviso	SACILE (12:17)	Vivalto	560	10%	10%	20%
RV	5729	13:34	13	34	Castelfranco	BASSANO DEL GRAPPA (12:25)	6 medie distanze	450	20%	30%	0%
R	2778	13:41	13	41	Adria	ADRIA (12:10)	ATR 120	230	20%	20%	50%
R	11027	13:46	13	46	Treviso	UDINE (11:31)	Vivalto	560	10%	0	0%
R	10026	13:50	13	50	Portogruaro	PORTOGRUARO CAORLE (12:38)	6 medie distanze	450	10%	20%	0%
RV	2452	13:56	13	56	Treviso	TRIESTE CENTRALE (10:56)	7 medie distanze	532	10%	10%	20%
R	5731	14:04	14	4	Castelfranco	CASTELFRANCO VENETO (13:04)	ETR 343	219	10%	20%	20%
R	20784	14:11	14	11	Padova	FERRARA (11:59)	TAF	476	10%	20%	0%
R	11029	14:16	14	16	Treviso	TREVISO CENTRALE (13:36)	Vivalto	560	10%	10%	0%
RV	2232	14:18	14	18	Padova	BOLOGNA CENTRALE (12:20)	8 medie distanze	614	20%	30%	40%
RV	2212	14:24	14	24	Portogruaro	TRIESTE CENTRALE (12:15)	7 medie distanze	532	10%	20%	20%
R	20829	14:25	14	25	Padova	PADOVA (13:35)	TAF	476	10%	0	0%
RV	2863	14:30	14	30	Treviso	CONEGLIANO (13:33)	Vivalto	560	10%	0	0%
RV	5733	14:34	14	34	Castelfranco	BASSANO DEL GRAPPA (13:25)	6 medie distanze	450	10%	20%	20%
R	2780	14:41	14	41	Adria	ADRIA (13:10)	ATR 120	230	20%	20%	0%
R	11031	14:46	14	46	Treviso	UDINE (12:31)	Vivalto	560	10%	10%	20%
RV	2717	14:48	14	48	Padova	VERONA PORTA NUOVA (13:21)	8 medie distanze	614	20%	20%	30%
R	10030	14:50	14	50	Portogruaro	PORTOGRUARO CAORLE (13:38)	6 medie distanze	450	10%	10%	10%
R	20831	14:55	14	55	Padova	VERONA PORTA NUOVA (12:42)	TAF	476	10%	0	0%
R	24831	14:55	14	55	Padova	VERONA PORTA NUOVA (12:42)	TAF	476	0%	10%	20%
RV	20970	14:56	14	56	Treviso	TRIESTE CENTRALE (11:26)	7 medie distanze	532	10%	0	0%
RV	2821	14:56	14	56	Treviso	UDINE (13:07)	7 medie distanze	532	0%	10%	0%
R	5735	15:04	15	4	Castelfranco	CASTELFRANCO VENETO (14:04)	ETR 343	219	10%	10%	0%
R	20786	15:11	15	11	Padova	ROVIGO (13:34)	TAF	476	10%	10%	0%
R	11033	15:16	15	16	Treviso	TREVISO CENTRALE (14:36)	Vivalto	560	10%	0	0%
RV	2234	15:18	15	18	Padova	BOLOGNA CENTRALE (13:20)	8 medie distanze	614	10%	10%	10%
RV	2682	15:20	15	20	Portogruaro	TRIESTE CENTRALE (13:15)	7 medie distanze	532	10%	10%	10%
R	20833	15:25	15	25	Padova	VICENZA (14:08)	TAF	476	10%	0	0%
RV	2865	15:30	15	30	Treviso	SACILE (14:17)	Vivalto	560	10%	10%	0%
RV	5737	15:34	15	34	Castelfranco	BASSANO DEL GRAPPA (14:25)	6 medie distanze	450	10%	10%	0%
R	2782	15:41	15	41	Adria	ADRIA (14:10)	ATR 120	230	20%	20%	20%
R	11035	15:46	15	46	Treviso	UDINE (13:31)	Vivalto	560	10%	10%	0%
RV	2719	15:48	15	48	Padova	VERONA PORTA NUOVA (14:21)	8 medie distanze	614	10%	0	0%
R	10034	15:50	15	50	Portogruaro	PORTOGRUARO CAORLE (14:38)	6 medie distanze	450	10%	10%	0%
R	24835	15:55	15	55	Padova	VERONA PORTA NUOVA (13:42)	TAF	476	10%	10%	0%
R	20835	15:55	15	55	Padova	VERONA PORTA NUOVA (13:42)	TAF	476	10%	0	0%
RV	2456	15:56	15	56	Treviso	TRIESTE CENTRALE (12:56)	7 medie distanze	532	10%	10%	10%
R	5739	16:04	16	4	Castelfranco	CASTELFRANCO VENETO (15:04)	ETR 343	219	10%	10%	10%
R	20788	16:11	16	11	Padova	FERRARA (13:59)	TAF	476	10%	10%	10%
R	11037	16:16	16	16	Treviso	TREVISO CENTRALE (15:36)	Vivalto	560	20%	10%	0%
RV	2236	16:18	16	18	Padova	BOLOGNA CENTRALE (14:22)	8 medie distanze	614	5%	5%	5%
RV	2214	16:20	16	20	Portogruaro	TRIESTE CENTRALE (14:15)	7 medie distanze	532	10%	10%	10%
R	20837	16:25	16	25	Padova	VICENZA (15:08)	TAF	476	10%	0	0%
RV	2867	16:30	16	30	Treviso	CONEGLIANO (15:33)	Vivalto	560	10%	10%	10%
RV	5741	16:34	16	34	Castelfranco	BASSANO DEL GRAPPA (15:25)	6 medie distanze	450	10%	10%	10%
R	2784	16:41	16	41	Adria	ADRIA (15:10)	ATR 120	230	10%	10%	0%
R	2786	16:41	16	41	Adria	PIOVE DI SACCO (15:47)	ATR 120	230	10%	10%	0%
R	11039	16:46	16	46	Treviso	UDINE (14:31)	Vivalto	560	20%	10%	10%
RV	2721	16:48	16	48	Padova	VERONA PORTA NUOVA (15:21)	8 medie distanze	614	5%	5%	5%
R	10038	16:50	16	50	Portogruaro	PORTOGRUARO CAORLE (15:38)	6 medie distanze	450	10%	5%	10%
R	20839	16:55	16	55	Padova	VERONA PORTA NUOVA (14:42)	TAF	476	10%	0	10%
R	24839	16:55	16	55	Padova	VERONA PORTA NUOVA (14:42)	TAF	476	0%	10%	0%
RV	20976	16:56	16	56	Treviso	TRIESTE CENTRALE (13:26)	7 medie distanze	532	10%	0	0%
R	5743	17:04	17	4	Castelfranco	CASTELFRANCO VENETO (16:04)	ETR 343	219	10%	5%	0%
R	20790	17:11	17	11	Padova	ROVIGO (15:36)	TAF	476	10%	0	0%
R	11041	17:16	17	16	Treviso	TREVISO CENTRALE (16:36)	Vivalto	560	20%	0	0%
RV	2238	17:18	17	18	Padova	BOLOGNA CENTRALE (15:20)	8 medie distanze	614	5%	5%	5%
RV	2684	17:20	17	20	Portogruaro	TRIESTE CENTRALE (15:15)	7 medie distanze	532	10%	10%	10%
R	20841	17:25	17	25	Padova	VICENZA (16:08)	TAF	476	10%	0	0%
RV	2869	17:30	17	30	Treviso	SACILE (16:17)	Vivalto	560	20%	0	0%
RV	5745	17:34	17	34	Castelfranco	BASSANO DEL GRAPPA (16:25)	6 medie distanze	450	10%	0	0%
R	2788	17:41	17	41	Adria	ADRIA (16:10)	ATR 120	230	10%	10%	0%
R	11043	17:46	17	46	Treviso	UDINE (15:31)	Vivalto	560	20%	0	0%
R	11045	17:46	17	46	Treviso	CONEGLIANO (16:40)	Vivalto	560	0%	10%	0%
RV	2723	17:48	17	48	Padova	VERONA PORTA NUOVA (16:21)	8 medie distanze	614	5%	5%	5%
R	10042	17:50	17	50	Portogruaro	PORTOGRUARO CAORLE (16:38)	6 medie distanze	450	10%	10%	0%
R	20843	17:55	17	55	Padova	VERONA PORTA NUOVA (15:42)	TAF	476	10%	10%	0%
RV	2460	17:56	17	56	Treviso	TRIESTE CENTRALE (14:56)	7 medie distanze	532	20%	10%	10%
R	5747	18:04	18	4	Castelfranco	CASTELFRANCO VENETO (17:04)	ETR 343	219	10%	10%	10%
R	20792	18:11	18	11	Padova	ROVIGO (16:34)	TAF	476	10%	10%	0%
R	20895	18:11	18	11	Padova	PADOVA (17:23)	TAF	476	0%	0	10%
R	11047	18:16	18	16	Treviso	TREVISO CENTRALE (17:36)	Vivalto	560	20%	10%	0%
RV	2240	18:18	18	18	Padova	BOLOGNA CENTRALE (16:20)	8 medie distanze	614	5%	5%	5%
RV	2216	18:20	18	20	Portogruaro	TRIESTE CENTRALE (16:15)	7 medie distanze	532	10%	10%	10%
R	20845	18:25	18	25	Padova	VICENZA (17:08)	TAF	476	10%	0	0%
RV	2871	18:30	18	30	Treviso	CONEGLIANO (17:33)	Vivalto	560	0%	10%	0%
RV	5749	18:34	18	34	Castelfranco	BASSANO DEL GRAPPA (17:25)	6 medie distanze	450	10%	10%	10%
R	2790	18:41	18	41	Adria	ADRIA (17:10)	ATR 120	230	10%	10%	10%

R	11049	18:46	18	46	Treviso	UDINE (16:31)	Vivalto	560	20%	10%	30%
RV	2725	18:48	18	48	Padova	VERONA PORTA NUOVA (17:21)	8 medie distanze	614	5%	5%	5%
R	10046	18:50	18	50	Portogruaro	PORTOGRUARO CAORLE (17:38)	6 medie distanze	450	10%	10%	10%
R	20847	18:55	18	55	Padova	VERONA PORTA NUOVA (16:42)	TAF	476	10%	10%	0%
R	24847	18:55	18	55	Padova	VERONA PORTA NUOVA (16:42)	TAF	476	0%	0	10%
RV	2825	18:56	18	56	Treviso	UDINE (17:07)	7 medie distanze	532	20%	0	0%
R	5751	19:04	19	4	Castelfranco	CASTELFRANCO VENETO (18:04)	ETR 343	219	10%	0	0%
R	20794	19:11	19	11	Padova	FERRARA (16:59)	TAF	476	10%	10%	0%
R	11051	19:16	19	16	Treviso	TREVISO CENTRALE (18:36)	Vivalto	560	10%	10%	0%
RV	2242	19:18	19	18	Padova	BOLOGNA CENTRALE (17:22)	8 medie distanze	614	5%	5%	5%
RV	2686	19:20	19	20	Portogruaro	TRIESTE CENTRALE (17:15)	7 medie distanze	532	10%	10%	10%
R	20849	19:25	19	25	Padova	VICENZA (18:08)	TAF	476	10%	0	0%
RV	2873	19:30	19	30	Treviso	SACILE (18:17)	Vivalto	560	10%	10%	0%
RV	5753	19:34	19	34	Castelfranco	BASSANO DEL GRAPPA (18:25)	6 medie distanze	450	10%	10%	0%
R	2792	19:41	19	41	Adria	ADRIA (18:10)	ATR 120	230	10%	10%	0%
R	11053	19:46	19	46	Treviso	UDINE (17:31)	Vivalto	560	10%	0	0%
RV	2727	19:48	19	48	Padova	VERONA PORTA NUOVA (18:21)	8 medie distanze	614	5%	5%	5%
R	10050	19:50	19	50	Portogruaro	PORTOGRUARO CAORLE (18:38)	6 medie distanze	450	10%	10%	0%
R	20851	19:55	19	55	Padova	VERONA PORTA NUOVA (17:42)	TAF	476	10%	10%	0%
RV	2464	19:56	19	56	Treviso	TRIESTE CENTRALE (16:56)	7 medie distanze	532	10%	10%	20%
R	5755	20:04	20	4	Castelfranco	CASTELFRANCO VENETO (19:04)	ETR 343	219	10%	10%	10%
R	20796	20:11	20	11	Padova	ROVIGO (18:34)	TAF	476	10%	0	0%
R	11055	20:16	20	16	Treviso	CONEGLIANO (19:11)	Vivalto	560	10%	0	0%
RV	2218	20:20	20	20	Portogruaro	TRIESTE CENTRALE (18:15)	7 medie distanze	532	10%	10%	10%
R	20853	20:25	20	25	Padova	VICENZA (19:08)	TAF	476	10%	0	0%
RV	2244	20:26	20	26	Padova	BOLOGNA CENTRALE (18:20)	8 medie distanze	614	5%	5%	5%
RV	2875	20:30	20	30	Treviso	SACILE (19:17)	Vivalto	560	10%	0	20%
RV	5757	20:34	20	34	Castelfranco	BASSANO DEL GRAPPA (19:25)	6 medie distanze	450	10%	10%	10%
R	11057	20:46	20	46	Treviso	UDINE (18:31)	Vivalto	560	10%	10%	20%
RV	2729	20:48	20	48	Padova	VERONA PORTA NUOVA (19:21)	8 medie distanze	614	5%	0	5%
RV	2735	20:48	20	48	Padova	VERONA PORTA NUOVA (19:21)	Vivalto	560	0%	5%	0%
R	10056	20:50	20	50	Portogruaro	PORTOGRUARO CAORLE (19:38)	6 medie distanze	450	10%	10%	10%
R	20855	20:55	20	55	Padova	VERONA PORTA NUOVA (18:42)	TAF	476	10%	10%	10%
R	24855	20:55	20	55	Padova	VERONA PORTA NUOVA (18:42)	TAF	476	10%	10%	10%
RV	2826	20:56	20	56	Treviso	TRIESTE CENTRALE (17:56)	7 medie distanze	532	10%	0	0%
RV	20990	20:56	20	56	Treviso	TRIESTE CENTRALE (17:26)	7 medie distanze	532	10%	0	0%
RV	2829	20:56	20	56	Treviso	UDINE (19:07)	7 medie distanze	532	0%	0	10%
R	5759	21:04	21	4	Castelfranco	CASTELFRANCO VENETO (20:04)	ETR 343	219	10%	0	0%
R	20798	21:11	21	11	Padova	ROVIGO (19:34)	TAF	476	5%	5%	0%
RV	2246	21:18	21	18	Padova	BOLOGNA CENTRALE (19:22)	8 medie distanze	614	5%	5%	5%
RV	2220	21:20	21	20	Portogruaro	TRIESTE CENTRALE (19:15)	7 medie distanze	532	10%	10%	10%
R	20857	21:25	21	25	Padova	VICENZA (20:08)	TAF	476	5%	0	0%
RV	2877	21:30	21	30	Treviso	SACILE (20:17)	Vivalto	560	5%	5%	5%
RV	5761	21:34	21	34	Castelfranco	BASSANO DEL GRAPPA (20:25)	6 medie distanze	450	10%	10%	0%
R	11059	21:46	21	46	Treviso	UDINE (19:31)	Vivalto	560	10%	0	10%
R	10058	21:50	21	50	Portogruaro	PORTOGRUARO CAORLE (20:38)	6 medie distanze	450	10%	10%	0%
R	20859	21:55	21	55	Padova	VERONA PORTA NUOVA (19:42)	TAF	476	5%	5%	0%
RV	2468	21:56	21	56	Treviso	TRIESTE CENTRALE (18:56)	7 medie distanze	532	5%	5%	5%
R	5763	22:04	22	4	Castelfranco	CASTELFRANCO VENETO (21:04)	ETR 343	219	10%	10%	10%
R	20861	22:49	22	49	Padova	VERONA PORTA NUOVA (20:36)	TAF	476	5%	0	5%
R	24861	22:49	22	49	Padova	VERONA PORTA NUOVA (20:36)	TAF	476	0%	5%	0%
RV	2833	22:56	22	56	Treviso	UDINE (21:07)	Vivalto	560	5%	0	0%
RV	2248	23:18	23	18	Padova	BOLOGNA CENTRALE (21:20)	8 medie distanze	614	5%	5%	5%
RV	2731	23:48	23	48	Padova	VERONA PORTA NUOVA (22:21)	8 medie distanze	614	5%	5%	5%
RV	2472	23:56	23	56	Treviso	TRIESTE CENTRALE (20:30)	7 medie distanze	532	5%	5%	5%

Appendix G: 2011 census data for historic Venice

Numero	Codice	Nome_Isola	Insula_Num	Superficie	Perimetro	Codice_Ses	sum_pop_11	Categoria	Tipo	Centroid_X	Centroid_Y
1	ALVI	Sant'Alvise	14	65808	1191	CN	381	city		12.327812	45.448163
2	ORTO	Madonna dell'Orto	14	62300	1117	CN	416	city		12.332765	45.446664
3	SENS	Sensa	40	32816	1080	CN	616	city		12.327027	45.447174
4	BRAZ	Brazzo	40	12197	485	CN	205	city		12.330738	45.446091
5	MORI	Mori	40	12044	489	CN	229	city		12.332802	45.445401
6	VALV	Santa Maria di Valverde	40	15651	528	CN	107	city		12.334682	45.444425
7	GIRO	San Girolamo	40	44437	1093	CN	746	city		12.324054	45.447185
8	ORME	Ormesini	40	23312	759	CN	631	city		12.328324	45.445912
9	MISE	Misericordia	40	30224	1016	CN	468	city		12.332504	45.444534
10	CHIO	Chiovere San Girolamo	7	30401	898	CN	631	city		12.323742	45.446190
11	GHET	Ghetto	7	6465	324	CN	112	city		12.326893	45.445353
12	SERV	Servi	13	13263	481	CN	18	city		12.331180	45.444259
13	MARZ	San Marziale	13	6412	439	CN	103	city		12.333141	45.443598
14	VEND	Ca'Vendramin	13	7682	429	CN	109	city		12.332770	45.443261
15	LEON	San Leonardo	28	167560	2619	CN	3167	city		12.325107	45.444940
16	MADD	Maddalena	13	28546	750	CN	507	city		12.330536	45.443004
17	FOSC	Santa Fosca	13	14397	596	CN	135	city		12.332195	45.442533
18	FELI	San Felice	12	13699	639	CN	258	city		12.333492	45.442130
19	MACE	Macello	28	52156	925	CN	424	city		12.318345	45.445321
20	GERE	San Geremia	28	248558	2825	CN	1295	city		12.320750	45.442433
21	ZAND	San Zan Degolα	30	69272	1156	SC	1175	city		12.325764	45.440638
22	ORIO	San Giacomo da l'Orio	31	35858	934	SC	669	city		12.327910	45.440693
23	MEGI	Megio	15	7130	410	SC	217	city		12.329047	45.441402
24	STAE	San Stae	15	21608	716	SC	472	city		12.329731	45.440886
25	MOCE	Ca'Mocenigo	15	9467	628	SC	200	city		12.330302	45.440454
26	MATE	S.M. Mater Domini	15	13696	672	SC	511	city		12.330539	45.439975
27	2TOR	Do Torri	16	19231	757	SC	744	city		12.331257	45.439727
28	CASS	San Cassian	16	32153	854	SP	833	city		12.332107	45.439210
29	SILV	San Silvestro	26	73083	1131	SP	1291	city		12.333719	45.438285
30	BOLD	San Boldo	8	16693	573	SP	370	city		12.328708	45.438864
31	POLO	San Polo	8	33599	1060	SP	423	city		12.329833	45.437385
32	MELO	Meloni	16	11333	449	SP	484	city		12.331381	45.437068
33	TOLE	Tolentini	32	105251	1946	SC	1533	city		12.323040	45.438563
34	FRAR	Frari	8	99909	1601	SP	1350	city		12.325836	45.437364
35	NOMB	Nomboli	8	23949	823	SP	444	city		12.328398	45.436744
36	ROMA	Piazzale Roma	17	95629	1497	SC	32	city		12.317422	45.437896
37	PAPA	Giardini Papadopoli	32	18251	588	SC	68	city		12.320677	45.438119
38	MART	Santa Marta	39	206877	2160	DD	1162	city		12.313711	45.433562
39	MAGG	Santa Maria Maggiore	17	41848	969	SC	491	city		12.317957	45.435967
40	MALC	Malcanton	18	20501	657	DD	184	city		12.321703	45.436317
41	PANT	San Pantalon	33	26009	686	DD	305	city		12.325683	45.435499
42	RIZZ	Ca'Rizzi	17	8982	448	SC	113	city		12.319233	45.435556
43	RAGU	Ragusei	18	37224	990	DD	358	city		12.321592	45.434899
44	CERE	Cereri	18	14593	593	DD	361	city		12.318939	45.434890
45	NICO	San Nicolƨ dei Mendicoli	18	60626	1311	DD	670	city		12.318236	45.433526
46	SEBA	San Sebastiano	39	58956	1106	DD	317	city		12.318426	45.431731
47	CARM	Carmini	19	133218	2770	DD	1287	city		12.323277	45.432828
48	BARN	San Barnaba	19	31750	985	DD	500	city		12.324099	45.432709
49	ROMI	Romite	19	21152	620	DD	269	city		12.323539	45.431584
50	CERC	Cerchieri	19	8920	430	DD	134	city		12.326340	45.432531
51	TROV	San Trovaso	19	33465	842	DD	266	city		12.325676	45.431397
52	ACCA	Accademia	20	69954	1187	DD	398	city		12.327885	45.430454
53	SVIO	San Vio	20	25018	894	DD	384	city		12.330290	45.430051
54	SPIR	Spirito Santo	20	42875	940	DD	432	city		12.331502	45.429379
55	GREG	San Gregorio	20	32340	767	DD	217	city		12.333566	45.429894
56	SALU	Salute	20	19543	668	DD	7	city		12.335329	45.430537
57	GESU	Gesuiti	2	49864	936	CN	520	city		12.337624	45.443690
58	RACC	Racchetta	12	7033	393	CN	236	city		12.335157	45.442815
59	ANDR	Sant'Andrea	12	7026	342	CN	133	city		12.336369	45.442750
60	SART	Sartori	12	8165	430	CN	208	city		12.338014	45.442385
61	BIRI	Biri	2	49132	1026	CN	1231	city		12.340121	45.441700
62	CORR	Corrente	12	6034	311	CN	249	city		12.335590	45.442202
63	2POZ	Do Pozzi	12	3336	250	CN	80	city		12.336312	45.441958
64	APOS	Santi Apostoli	12	76525	1320	CN	1337	city		12.336173	45.441142
65	PANA	Panada	2	30348	976	CN	688	city		12.341048	45.440431
66	ZANI	San Zanipolo	25	111677	1394	CS	889	city		12.343530	45.439583
67	VIGN	San Francesco de la Vigna	6	87345	2198	CS	699	city		12.348774	45.437931
68	BACI	Bacini Arsenale	6	224209	3166	CS	41	city		12.358133	45.438255
69	CANC	San Cancian	36	27473	841	CN	543	city		12.338017	45.439853
70	MIRA	S.M. dei Miracoli	36	5620	318	CN	118	city		12.339401	45.439218
71	GRIS	San Zuane Grisostomo	36	15751	543	CN	286	city		12.337210	45.438969
72	MARI	Santa Marina	3	14411	517	CS	331	city		12.339027	45.438304
73	BORG	Borgoloco	3	5457	314	CS	73	city		12.340232	45.438106
74	FORM	Santa Maria Formosa	3	23929	640	CS	381	city		12.341371	45.437582
75	LATE	San Zuane Laterano	4	5878	418	CS	95	city		12.343551	45.437931
76	SEVE	San Severo	4	23452	693	CS	375	city		12.343519	45.436844
77	BORT	San Bortolomio	36	38311	842	SM	476	city		12.336744	45.437166

78	FAVA	Santa Maria della Fava	3	34049	822	CS	770	city		12.339105	45.436999
79	QUER	Querini Stampalia	4	20380	622	CS	330	city		12.342174	45.436346
80	LUCA	San Luca	35	47964	943	SM	385	city		12.334915	45.435814
81	ANZO	Sant'Anzolo	35	41420	1098	SM	570	city		12.332492	45.434929
82	GARZ	Ca'Garzoni	11	8205	431	SM	111	city		12.330727	45.435090
83	STEF	Santo Stefano	11	80004	1695	SM	797	city		12.329575	45.433619
84	DUCA	Duca	11	7742	409	SM	121	city		12.329026	45.432615
85	MAUR	San Maurizio	11	20796	702	SM	299	city		12.331544	45.432460
86	DUOD	Ca'Duodo	1	6504	600	SM	134	city		12.332388	45.432690
87	ZOBE	Santa Maria Zobenigo	1	12317	510	SM	67	city		12.333023	45.432322
88	FANT	San Fantin	1	16836	509	SM	138	city		12.333890	45.433890
89	MOIS	San MoisΘ	1	29297	711	SM	125	city		12.334596	45.432573
90	REAL	Giardinetti Reali	10	6913	362	SM	17	city		12.338208	45.432941
91	GALL	San Gallo	10	18613	538	SM	329	city		12.337222	45.435003
92	MARC	San Marco	10	114709	2066	SM	568	city		12.338053	45.434192
93	FILI	San Filippo e Giacomo	4	34188	892	CS	368	city		12.341406	45.434945
94	ZACC	San Zaccaria	4	32113	731	CS	227	city		12.343332	45.434662
95	LORE	San Lorenzo	24	42913	1081	CS	583	city		12.345109	45.435899
96	BRAG	Bragora	24	90559	1528	CS	1812	city		12.347135	45.435617
97	TERN	Santa Ternita	5	23351	691	CS	642	city		12.348763	45.436035
98	MRTN	San Martin	24	23276	686	CS	424	city		12.349181	45.433808
99	ARSE	Arsenale	6	122001	2675	CS	192	city		12.353678	45.434273
100	DANI	San Daniel	9	24944	875	CS	374	city		12.356369	45.434020
101	RUGA	Campo Ruga	9	20684	723	CS	504	city		12.357429	45.433776
102	PIER	San Piero	37	59835	1039	CS	512	city		12.359920	45.433903
103	ANA	Sant'Ana	9	141624	1780	CS	2833	city		12.354855	45.431757
104	ISEP	San Isepo	9	85575	1303	CS	333	city		12.357634	45.429370
105	ELEN	Sant'Elena	38	224780	2666	CS	1875	city		12.361295	45.428661
106	STAD	Stadio Sant'Elena	38	101075	1641	CS	4	city		12.364920	45.426949
107	FISO	Sacca Fisola	21	105837	1371	GD	1403	city		12.315078	45.427680
108	AMAV	AMAV	21	20920	753	GD	0	city		12.312107	45.425767
109	PISC	Piscina Comunale	21	13886	480	GD	0	city		12.313759	45.425929
110	SACB	Sacca San Biagio	21	7721	411	GD	0	city		12.315241	45.425980
111	STUC	Molino Stucky	22	42102	992	GD	188	city		12.318912	45.426998
112	BIAG	San Biagio	22	37897	819	GD	310	city		12.321629	45.427112
113	CONV	Convertite	22	57758	984	GD	370	city		12.320932	45.425407
114	EUFE	Sant'Eufemia	22	89585	1426	GD	1019	city		12.324361	45.425293
115	PALA	Palada	22	22066	639	GD	266	city		12.327599	45.425513
116	JUNG	Junghans	22	26400	689	GD	269	city		12.326689	45.424132
118	ZITT	Zittelle	23	207774	2095	GD	1577	city		12.337782	45.425191
119	GIOR	San Giorgio	23	98183	1539	GD	4	city		12.344211	45.428024
120	INCE	Inceneritore	21	37948	911	GD	0	city		12.309497	45.426843
121	PORT	Stazione Marittima	39	428156	4886	SC	20	city		12.310575	45.437706
122	TRON	Tronchetto	39	187554	2272	SC	0	city		12.306420	45.441524
123	GIOB	San Giobbe	28	39332	846	CN	763	city		12.319895	45.444170
124	DIPO	Diporto Velico	38	2937	552	CS	146	city		12.364978	45.430408
125	DGIO	Darsena San Giorgio	23	1019	573	GD	4	city		12.344805	45.429935
126	MICH	S. Michele	0	159099	2130	CS		city		12.346997	45.446839

Appendix H: Annuario del Turismo overnight tourist data by year

Year	Overnighter
2002	6033325
2003	6212412
2004	6930073
2005	7670433
2006	8245154
2007	8842874
2008	8487539
2009	8445911
2010	8521247
2011	9417872
2012	9310132
2013	9778225
2014	9983416

Appendix I: Weekday Train Extrapolation

TIME	TOTAL	Overnighter	Daytrippers	Commuters
7:30	234	1	13	220
7:34	146	4	25	117
7:48	287	2	19	266
7:50	211	0	23	188
8:04	292	6	35	251
8:10	313	7	29	277
8:16	400	6	65	329
8:18	460	10	81	369
8:25	191	5	26	160
8:34	403	13	61	329
8:41	150	6	41	103
8:48	461	14	103	344
8:55	132	3	44	85
9:00	311	17	127	167
9:04	174	7	100	67
9:11	109	5	68	36
9:16	192	16	79	97
9:18	477	28	243	206
9:23	146	0	123	23
9:40	224	31	179	14
9:46	368	24	295	49
9:55	142	9	109	24

10:04	138	4	109	25
10:11	96	15	71	10
10:18	265	18	227	20
10:34	164	7	122	35
10:41	44	0	38	6
10:48	189	17	151	21
10:55	110	8	93	9
11:04	74	9	52	13
11:18	291	30	247	14
11:20	49	6	33	10
11:34	118	10	83	25

Percent DT	**PERCENT O**	**PERCENT C**
0.055555556	0.004273504	0.94017094
0.171232877	0.02739726	0.801369863
0.066202091	0.006968641	0.926829268
0.109004739	0	0.890995261
0.119863014	0.020547945	0.859589041
0.092651757	0.022364217	0.884984026
0.1625	0.015	0.8225
0.176086957	0.02173913	0.802173913
0.136125654	0.02617801	0.837696335
0.151364764	0.032258065	0.816377171
0.273333333	0.04	0.686666667
0.223427332	0.030368764	0.746203905
0.333333333	0.022727273	0.643939394

0.408360129	0.054662379	0.536977492
0.574712644	0.040229885	0.385057471
0.623853211	0.04587156	0.330275229
0.411458333	0.083333333	0.505208333
0.509433962	0.05870021	0.431865828
0.656768699	0	0.2002222
0.799107143	0.138392857	0.182299393
0.801630435	0.065217391	0.133152174
0.767605634	0.063380282	0.169014085
0.789855072	0.028985507	0.18115942
0.739583333	0.15625	0.104166667
0.856603774	0.067924528	0.075471698
0.743902439	0.042682927	0.213414634
0.863636364	0	0.136363636
0.798941799	0.08994709	0.111111111
0.845454545	0.072727273	0.081818182
0.702702703	0.121621622	0.175675676
0.848797251	0.103092784	0.048109966
0.673469388	0.12244898	0.048109966
0.703389831	0.084745763	0.048109966

Month	**Month**	**days in month**	**weekdays/mth**
Jan	1	31	21
Feb	2	28	21
Mar	3	31	23

Apr	4	30	21
May	5	31	22
Jun	6	30	22
Jul	7	31	21
Aug	8	31	23
Sep	9	30	22
Oct	10	31	21
Nov	11	30	21
Dec	12	31	23

Length mm (coses)	**Commuters/day**	**Commuters weekday/month**
2	3399.130435	71381.73913
2.4	4078.956522	85658.08696
2.4	4078.956522	93816
2.3	3909	82089
2.2	3739.043478	82258.95652
2.1	3569.086957	78519.91304
1.6	2719.304348	57105.3913
1.1	1869.521739	42999
2.5	4248.913043	93476.08696
2.4	4078.956522	85658.08696
2.3	3909	82089
2.1	3569.086957	82089

length mm (COSES)	Daytrippers/day	Daytrippers in a weekday/month
2.2	2446.714286	51381
3.2	3558.857143	74736
2.7	3002.785714	69064.07143
4.4	4893.428571	102762
4.5	5004.642857	110102.1429
4.9	5449.5	119889
5.3	5894.357143	123781.5
5.5	6116.785714	140686.0714
5.2	5783.142857	127229.1429
4.5	5004.642857	105097.5
2.8	3114	65394
2	2224.285714	51158.57143

Appendix J: Weekend Train Extrapolation

TIME	TOTAL	Overnighter	Daytrippers	Commuters
8:18	80	9	12	59
8:24	138	120	15	3
8:34	104	3	17	84
8:41	51	2	14	35
8:48	145	14	62	69
8:55	46	2	8	36
9:00	90	5	38	47
9:11	30	0	11	19
9:16	55	8	26	21
9:20	93	9	47	37

Percent DT	PERCENT O	PERCENT C
0.15	0.1125	0.7375
0.108695652	0.869565217	0.75
0.163461538	0.028846154	0.807692308
0.274509804	0.039215686	0.68627451
0.427586207	0.096551724	0.6122222
0.35121333	0.043478261	0.52222
0.422222222	0.055555556	0.522222222
0.366666667	0	0.4555555
0.472727273	0.145454545	0.381818182
0.505376344	0.096774194	0.361283883

Month	Month	days in month	weekend days /mth
Jan	1	31	10
Feb	2	28	7
Mar	3	31	8
Apr	4	30	9
May	5	31	9
Jun	6	30	8
Jul	7	31	10
Aug	8	31	8
Sep	9	30	8
Oct	10	31	10
Nov	11	30	9
Dec	12	31	8

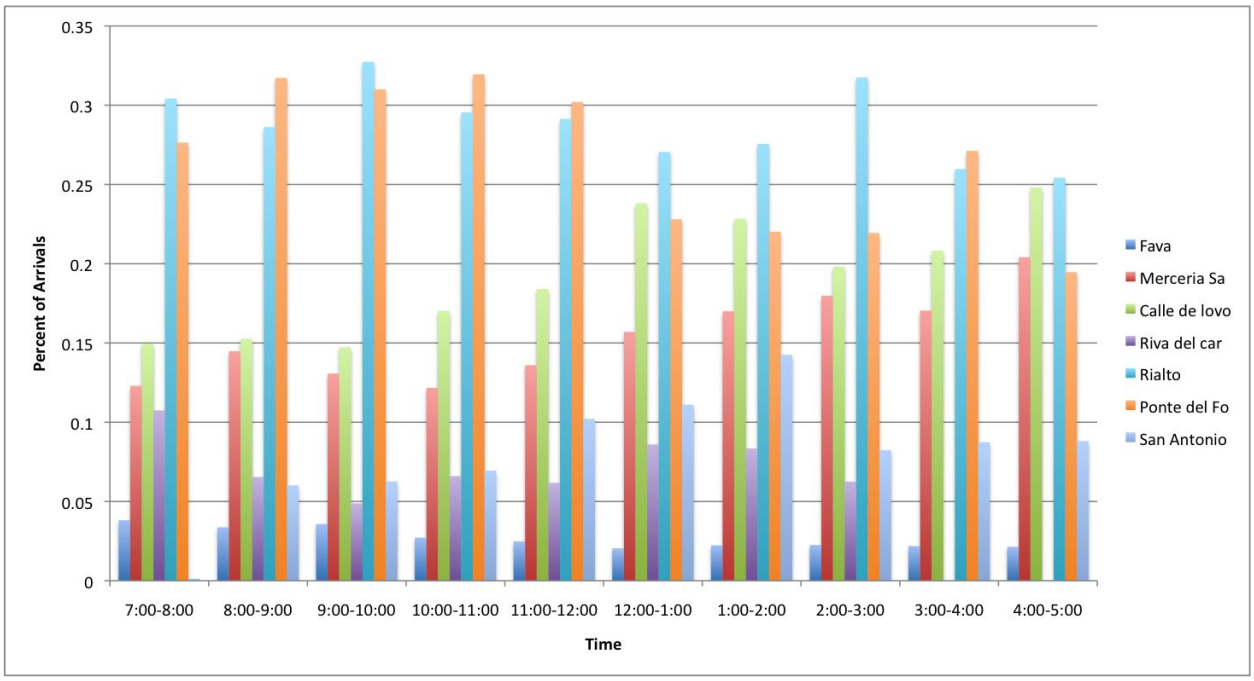
Length mm (coses)	Commuters weekend/day	Commuters weekend day /month
2	1536.71275	15367.1275
2.4	1844.0553	12908.3871
2.4	1844.0553	14752.4424
2.3	1767.219662	15904.97696
2.2	1690.384025	15213.45622
2.1	1613.548387	12908.3871
1.6	1229.3702	12293.702

1.1	845.1920123	13245.43
2.5	1920.890937	15367.1275
2.4	1844.0553	18440.553
2.3	1767.219662	15904.97696
2.1	1613.548387	12908.3871

length mm (COSES)	**Daytrippers in a weekend day /day**	**Daytrippers in a weekend day/month**
2.2	1082.258065	10822.58065
3.2	1574.193548	11019.35484
2.7	1328.225806	10625.80645
4.4	2164.516129	19480.64516
4.5	2213.709677	19923.3871
4.9	2410.483871	19283.87097
5.3	2607.258065	22344.43
5.5	2705.645161	21645.16129
5.2	2558.064516	20464.51613
4.5	2213.709677	22137.09677
2.8	1377.419355	12396.77419
2	983.8709678	7870.967742

Appendix K: San Bortolomio Island Count

	Calle Feva							Mercería San Zulian						Calle de lovo						
Time	Count in	Count out	Hourly	Count In/hour	Count Out/hou	INFLUX DIST	OUTFLOW DIS	Count in	Count out	Count In/hour	Count Out/hou	INFLUX DIST	Outflow Dist	Time	Count in	Count out	HOURLY	Count In/hour	Count Out/hou	INFLUX DIST	Outflow DIST
7:15 AM	5	1	7:00 - 8:00	59	28	0.03818770227	0.01361867704	10	26	190	413	0.1229773463	0.2008754864	7:15 AM	17	46	7:00 - 8:00	231	623	0.1495145631	0.3030155642
7:30	11	1						21	56					7:30	39	106					
7:45	16	9						60	129					7:45	69	190					
8:00 AM	27	17	8:00 - 9:00	51	65	0.03370786517	0.03248511099	99	202	219	360	0.1447455387	0.1949106659	8:00 AM	106	281	8:00 - 9:00	231	490	0.1526768011	0.2652950731
8:15	42	27						171	273					8:15	150	374					
8:30	53	43						222	363					8:30	202	468					
8:45	65	56						258	459					8:45	265	312					
9:00 AM	78	77	9:00 - 10:00	134	125	0.03575240128	0.03338675214	318	562	490	711	0.1307363927	0.1899038462	9:00 AM	337	771	9:00 - 10:00	552	982	0.1472785488	0.2622863248
9:15	104	110						379	682					9:15	447	958					
9:30	141	141						499	879					9:30	576	1271					
9:45	176	168						633	1046					9:45	725	1480					
10:00 AM	212	202	10:00 - 11:00	164	165	0.02718832891	0.02823408624	808	1273	734	1032	0.1216843501	0.1765913756	10:00 AM	889	1753	10:00 - 11:00	1027	1317	0.1702586207	0.2253593429
10:15	255	241						930	1477					10:15	1121	2042					
10:30	292	290						1085	1740					10:30	1346	2405					
10:45	346	344						1386	2048					10:45	1622	2726					
11:00 AM	376	367	11:00 - 12:00	157	235	0.02484963596	0.03238699008	1542	2305	859	1338	0.1359607471	0.184399118	11:00 AM	1916	3070	11:00 - 12:00	1163	1158	0.1840772396	0.1595920617
11:15	423	442						1808	2727					11:15	2118	3353					
11:30	465	491						2007	3057					11:30	2399	3620					
11:45	497	542						2232	3351					11:45	2711	3903					
12:00 PM	533	602	12:00 - 1:00	138	244	0.0204595997	0.0358086292	2401	3643	1059	1133	0.157005189	0.1662753155	12:00 PM	3079	4228	12:00 - 1:00	1606	1046	0.238102298	0.1535074846
12:15	557	664						2684	3953					12:15	3407	4531					
12:30	599	742						2928	4237					12:30	3842	4792					
12:45	637	801						3177	4503					12:45	4236	5041					
1:00 PM	671	846	1:00 - 2:00	131	257	0.02235876429	0.04091053805	3460	4776	998	1156	0.1699948797	0.1840178287	1:00 PM	4685	5274	1:00 - 2:00	1338	952	0.2283666155	0.1515440942
1:15	705	907						3743	5144					1:15	5051	5534					
1:30	732	958						4011	5416					1:30	5368	5755					
1:45	756	1007						4239	5689					1:45	5658	5952					
2:00 PM	802	1103	2:00 - 3:00	140	168	0.02255517964	0.02699228792	4456	5932	1116	1212	0.1797970034	0.1947300771	2:00 PM	6023	6226	2:00 - 3:00	1230	1028	0.1981633639	0.1648457584
2:15	824	1142						4708	6229					2:15	6299	6427					
2:30	876	1189						5009	6554					2:30	6646	6663					
2:45	897	1220						5265	6885					2:45	6994	6965					
3:00 PM	942	1271	3:00 - 4:00	147	200	0.02187825569	0.02735978112	5572	7144	1145	1158	0.1704122637	0.1584131327	3:00 PM	7263	7252	3:00 - 4:00	1400	1399	0.2083643399	0.1913816689
3:15	972	1330						5859	7417					3:15	7511	7596					
3:30	998	1365						6164	7766					3:30	7865	7995					
3:45	1030	1406						6459	8012					3:45	8251	8268					
4:00 PM	1089	1471	4:00 - 5:00	134	231	0.02145373039	0.03532110092	6717	8302	1275	866	0.2041306436	0.1324159021	4:00 PM	8653	8651	4:00 - 5:00	1550	1262	0.2481588216	0.1929663609
4:15	1150	1519						7032	8549					4:15	8995	8952					
4:30	1168	1611						7418	8766					4:30	9414	9253					
4:45	1195	1670						7718	9004					4:45	9795	9615					
5:00 PM	1223	1702	5:00 - 6:00	159	143	0.03112764291	0.02337365152	7992	9168	1250	801	0.2447141738	0.1309251389	5:00 PM	10203	9913	5:00 - 6:00	1603	1048	0.3138214565	0.1712978097
5:15	1303	1742						8329	9396					5:15	10641	10206					
5:30	1333	1775						8631	9607					5:30	11069	10491					
5:45	1352	1825						8951	9763					5:45	11421	10730					
6:00 PM	1382	1845	6:00 - 7:00	132	173	0.03013010728	0.0319306017	9242	9969	868	638	0.1961282812	0.1177556294	6:00 PM	11806	10961	6:00 - 7:00	1461	1066	0.3334855056	0.1967515688
6:15	1421	1915						9469	10140					6:15	12126	11164					
6:30	1441	1958						9729	10314					6:30	12515	11427					
6:45	1468	2007						9974	10467					6:45	12914	11783					
7:00 PM	1514	2018						10110	10607					7:00 PM	13267	12027					


0.35
0.3
0.25
0.2
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0
Percent of Arrivals
7:00-8:00
8:00-9:00
9:00-10:00
10:00-11:00
11:00-12:00
12:00-1:00
1:00-2:00
2:00-3:00
3:00-4:00
4:00-5:00
Time
Fava
Merceria Sa
Calle de lovo
Riva del car
Rialto
Ponte del Fo
San Antonio

Appendix L: Guide to Safety at Sports Grounds

10.6 Recommended rates of passage

The informative annex of BS EN 13200-1:2003 (see Bibliography) for flow capacity advises that, for a width of 1.2m:

a. on a stepped surface 79 people can reasonably exit in 1 minute (equal to 66 spectators per metre width per minute)

b. on a level surface 100 people can reasonably exit in 1 minute (equal to 82 spectators per metre width per minute)

For new construction: it is recommended that new sports grounds or sections of grounds should be designed in accordance with the rates of passage in the British Standard.

10.7 Egress time

It is emphasised that there is a difference between egress times and emergency evacuation times.

The egress time is the total time in which all spectators can, in normal conditions, leave an area of viewing accommodation and enter into a free flowing exit system. It does not include the time taken to negotiate the entire exit route.

(For a definition of emergency evacuation times, see Section 10.9.)

The normal maximum egress time for sports grounds is eight minutes.

If for any reason – for example, there are not enough exits – spectators cannot exit within eight minutes, a reduction of the final capacity may be required (see Chapter 2).

The limit of eight minutes has been set as a result of research and experience, which suggests that within this period spectators are less likely to become agitated, or experience frustration or stress, provided they enter an exit system at an acceptable rate, or are familiar with the sports ground and/or can identify their point of exit.

In certain circumstances it may be appropriate to apply a shorter egress time than eight minutes; for example, if the design or management of the viewing accommodation is such that regular observation shows that spectators become agitated or experience frustration or stress in periods of under eight minutes.

It should also be recognised that in many circumstances spectators will willingly take longer than eight minutes to leave; for example, in order to watch scoreboards, hear additional announcements or simply wait for the crowds to disperse. This practice must not be considered a factor in the determination of the egress time.

10.8 Design and management of exit systems

The design and management of exit systems should take into account the following:

a. **Movement**
Once spectators have passed into the exit system they should be able to keep moving throughout its length.

b. **Alternative exits**
In the event of an incident which renders the usual exit route unusable, spectators should be able to use an alternative exit route or routes.